

USBM Contract H0230015

SURVEY OF DUST CONTROL RESEARCH

(BCR Report L-517)

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U. S. BUREAU OF MINES CONTRACT REPORT (H0230015)

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Bureau of Mines Open File Report 51-73



DEPARTMENT OF THE INTERIOR

U. S. BUREAU OF MINES

WASHINGTON, D. C.

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May, 1973

Mr. Frank Pavlich, Chief
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U.S. Bureau of Mines
Section of Contracts, Building 20
Denver Federal Center
Denver, Colorado 80225

SUBJECT: FINAL REPORT - USBM CONTRACT H0230015

Dear Mr. Pavlich,

This report summarizes more than three months of intensive investigation into research efforts being undertaken in the following two problem areas associated with the mining of coal:

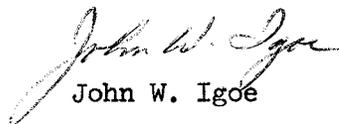
1. Respirable dust sampling instruments,
2. Methods of control of respirable and float dust.

Based on the information obtained, industry recommendations have been made for future research to fill the voids in the present programs as well as delineating those research programs, ongoing or new, which should have high priority.

Cost figures for recommended programs are order-of-magnitude estimates and could change once the individual step-by-step scope of work has been formulated.

Excellent cooperation was obtained from all divisions of the Federal agencies contacted as well as from all segments of the coal industry.

Very truly yours,


John W. Igoe

JWI:RDS/bic
2202

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FOREWORD

This report was prepared by Bituminous Coal Research, Inc., under USBM Contract No. H0230015. The contract was initiated under the Coal Mine Health and Safety Program. It was administered under the technical direction of TCMRC, with Mr. Kelly Strebbig acting as the technical project officer. Mr. Frank Pavlich was the contract administrator for the Bureau. This report is a summary of the work recently completed as part of this contract during the period November 15, 1972, to March 30, 1973. This report was submitted by the authors on March 29, 1973. This technical report has been reviewed and approved.

BITUMINOUS COAL RESEARCH, INC.
SPONSORED RESEARCH PROGRAM

SURVEY OF RESEARCH
IN
DUST SAMPLING INSTRUMENTATION AND DUST CONTROL

I. INTRODUCTION

This report is in fulfillment of Contract No. H0230015 awarded to Bituminous Coal Research, Inc., on November 15, 1972. The scope of the work under this contract was to perform a two-phase survey for the purpose of determining the status of work in the following specific areas of industry needs under the Technology Transfer Program and to increase industry's awareness of research efforts under the Federal Coal Mine Health and Safety Act of 1969 (P.L. 91-173):

1. Research and development of respirable dust sampling instruments which will more accurately collect the respirable dust as defined by the Federal Coal Mine Health and Safety Act of 1969.

2. Development of a better means of control of respirable dust and float dust.

A. Scope of Work

Phase I of the work required under this contract was to accomplish the following:

1. Determination of the basis for, and the nature of, the two industry needs above enumerated by discussion with the industry group that advanced them, and with others, to amplify their ideas and input.

2. Inventory the related research and development being performed by the Bureau of Mines and industry.

The inventory of related research and development being performed by the Bureau of Mines is required by the contract to be compiled from the following: (1) review of the September, 1971 to date issues of the Mining Research Contract Review, prepared by the Bureau of Mines; (2) determination of in-house research programs of the Bureau of Mines by contacting appropriate individuals at the Pittsburgh Mining and Research Center, Pittsburgh Technical Support Center and the Twin Cities Mining Research Center. An inventory of industry-wide research is required to be determined by contacting key personnel of the six to ten largest coal companies producing from underground mines and those companies and organizations known by the Bureau and/or Bituminous Coal Research, Inc., to be performing such research.

The Phase I Report (BCR Report L-495) was transmitted on January 12, 1973 to Bureau of Mines and was accepted.

2.

The scope of work in Phase II is defined in the contract to consist of the following:

1. "The Contractor shall evaluate each of the contracts on the approved Phase I list with regard to their contribution toward meeting the technologic need previously established. This evaluation shall be in narrative form and shall include the following information:

- a. Organization performing research.
- b. Descriptive project title.
- c. Objective of research project. Project start and scheduled completion.
- d. Summary of project progress to date.
- e. Project funding.
- f. Enumeration of the technologic deficiencies remaining to date and, for ongoing projects not yet complete, those deficiencies which the Contractor anticipates will remain upon completion of the projects with regard to the need previously defined.

This information shall be obtained through personal visitations to the aforementioned Bureau of Mines' personnel and key coal industry personnel. Technical project officers on Bureau of Mines' sponsored contracts shall be contacted either by phone or in person when up-dating or acquiring additional information as needed.

2. Upon completion of the field survey, the Contractor shall prepare a Statement of Work for a cost-effective research project or projects which are required to eliminate the technologic deficiencies which still exist with regard to satisfying the requirements of P.L. 91-173 in consideration of the integrated evaluation of all known research projects addressed to the particular research area. Each such Statement of Work so prepared shall be accompanied by an order of magnitude estimate by the Contractor of the cost of the performance of such research by the Contractor or a designated equally proficient and professional organization."

B. Historical Background

The research needs of the coal mining industry resulting from P.L. 91-173 were first discussed September 23, 1970 at a meeting between Bureau and coal industry personnel. The industry representatives suggested sixteen areas for research activity. Included were three in the areas of dust control and dust sampling instrumentation, as follows: (1) respirable and float dust control; (2) improved accuracy of sampling instruments for respirable dust and (3) improved systems of face ventilation for controlling and directing ventilating currents. This meeting was held shortly after the operative date of Title II-Interim Mandatory Health Standards, the section which initiated the dust sampling program.

The industry has now had approximately two and one-half years of experience under the Act. Consequently, its present views as to the research needs of the industry on dust sampling instrumentation and dust control are based upon its experience in endeavoring to comply with the respirable dust standards legislated by Congress. The industry has also had the experience of evaluating the methods and procedures developed by the Bureau in the enforcement of the dust standards with the approved instruments for sampling respirable dust and the degree to which these procedures have recognized the instrumental and human errors in air sampling and in analyzing gravimetric dust samples. This time period has also provided the opportunity for research by major coal producers in the areas of (1) the accuracy and reproducibility of measurements with approved air samplers; (2) the correlation between instruments obtained by paired MRE and personal samplers; and (3) control of respirable dust.

C. Procedure

The provisions of this contract for evaluating projects directed towards meeting the technologic needs previously established were met by first assembling the dossier of "Project Briefs" which is included in the Appendix. These briefs were collected during the conduct of personal interviews with key government and industry personnel who were closely allied with these research projects. The personal interviews were supplemented with telephone interviews. During the conduct of interviews with industry personnel, the needs of the industry as described previously were discussed and redefined. This report is based on the data collected while assembling the "Project Briefs" and discussing the needs of the industry.

הנהגות מנהל המבחנים

II. SUMMARY

This report reviews, from the point of view of selected coal producers, the contribution made by both in-house and contract research by the Bureau of Mines and other governmental agencies in meeting the needs of the industry for accurate dust sampling instrumentation and for improved dust control technology. This review, combined with an evaluation of coal industry research, has been utilized to make recommendations for future research to overcome remaining technologic difficulties.

The survey conducted under this Contract included a review of 17 research projects conducted "in-house" by the Bureau involving a 1972 cost of \$1,762,650¹, 23 contract research projects funded by the Bureau at a 1972-1973 cost of \$2,928,000, 17 projects funded by NIOSH and other governmental organizations at a cost of \$538,000, and 89 company-funded research projects conducted by coal producers. The cost of the company-funded projects (\$2,278,000 for 48 projects) is of limited accuracy due to inability to obtain sufficient cost data in all cases.

A review of the number and type of contract and in-house research projects reveals the need for establishing a priority rating for research activities with input from industry. While no doubt some effort was made in this area, the pressures of time and other problems, such as enforcement, which the Bureau immediately faced in implementing P.L. 91-173 appeared to prevent a major effort in this direction. It would appear that unless such a priority is established, areas which should receive the earliest attention can be overlooked, thereby adversely affecting the Bureau's research program. Consequently, it would appear appropriate for the Bureau to establish, in addition to the Secretary's Advisory Committee, an industry advisory group consisting of professional individuals, experienced in coal mine health and safety work, especially the assessment of respirable dust instrumentation and dust control technology.

A. Research in Specific Area Industry Needs

1. Respirable Dust Sampling Instruments: The establishment of the MRE as the standard instrument for measuring coal mine dust, through the enactment of P.L. 91-173, necessitated a crash program by the Bureau to familiarize itself with this and other gravimetric dust samplers and to develop a correlation between the performance of the MRE and that of other samplers, principally the USAEC personal gravimetric sampler. Much of the knowledge utilized was derived from laboratory studies by the Bureau and others.

Field testing of approved gravimetric samplers by the paired instrument technique conducted by coal industry investigators and others has demonstrated their erratic performance.

These studies raise a major question as to whether or not measurements derived from personal gravimetric sampling (USAEC) can be accurately converted into MRE equivalent values. Therefore, there is a major need to re-evaluate and re-examine the state of the art of gravimetric dust sampling for the enforcement of dust standards, through field investigations or research under simulated mining conditions.

¹ Excluding cost of 3 PTS projects.

6.

No presently available gravimetric instrument collects respirable dust limited to the definition in P.L. 91-173, namely, only particles 5 microns or less in size; nor do they collect all the respirable dust. Furthermore, the MRE instrument and the USAEC sampler collect different percentages of respirable dust at each unit of particle diameter (i.e. 1, 2, 3, 4, and microns).

The industry indicates that it does not question the need for improved instrumentation but, as will be explained later, it is felt that the principal effort should be on effectively reducing to practice the present concept of the personal sampler and that the funding of instrumentation research based on new concepts should receive a lower priority.

The industry feels that more efforts are necessary to relate the present dust conditions as measured by the current personal samplers to any evidence of incipient pneumoconiosis in new miners as well as any progression of it in older miners who were formerly exposed to higher dust concentrations.

The recent lowering of the dust standard to 2.0 mg/m³ amplifies the urgent need to thoroughly evaluate the accuracy and reproducibility of gravimetric dust measurements obtained under field conditions.

The coal producers feel that the Bureau and NIOSH should support epidemiological studies of miners, particularly the young miners who entered the industry after enactment of P.L. 91-173. It is felt that only this group will provide the answer to the adequacy or inadequacy of dust standards.

2. Improved Methods of Respirable and Float Dust Control: The coal industry believes that the health of coal miners can be best advanced by the Bureau's concentrating its research program in the following areas: (1) practical means of minimizing dust generation; (2) practical means of minimizing dust dispersion; and (3) practical means of maximizing dust removal from the mine atmosphere.

The general principles of coal mine dust control are well recognized. However, there is a need to refine and develop these principles in further detail so that each mine can select the best combination of measures to meet its conditions. This research should include studies in the following areas: (1) application of the "wet head" design to all cutting machines in different coal seams; (2) design and application of machine-mounted collectors and integral pick-up hood for application on existing machines; (3) development of self-advancing curtain or tubing with machine advancement as part of the development of more automatic mining techniques; (4) development of optimum face ventilation system designs for dust and gas control; (5) new machine designs with integrated dust control or suppression systems optimized for first cost, effectiveness of dust control, serviceability, etc.; (6) study and development of water infusion practices; and (7) study of the optimum type, number, and location of water sprays.

Thorough investigation needs to be undertaken of air movement at the coal face. This should include development of data on the direction and magnitude of air movement in the area between the machine operator and the coal face for different ventilation systems and ventilation rates.

The advantages and disadvantages of machine-mounted scrubbers, of diffusers or of air-water aspirators to maximize air flow over the machine operator should be evaluated.

Remote-controlled mining machines with integral conveyors should be considered as a means of minimizing the exposure of workers to dust generated at the coal face.

The special dust control problems of low coal seams should be studied and control methods developed.

B. Evaluation of Government and Industry Projects

The government-funded research projects reviewed in this study include those supported by the Bureau, the National Institute of Occupational Safety and Health, and the Commonwealth of Pennsylvania. Industry research projects were self-supported and were primarily of the short-term, applied-research type to determine the application of Bureau or other governmental agency proposals or requirements.

1. Government-funded Projects: The Bureau is commended for its recognition of the many areas requiring research. However, it is the opinion of the industry that emphasis should be given to applied, or field research, as contrasted to laboratory experiments where test conditions are not necessarily characteristic of those in mining operations.

Seventeen "in-house" projects were in progress, or had been completed by the Bureau. Eight of these projects were undertaken by the Pittsburgh Mining & Safety Research Center (PMSRC); six projects by the Twin Cities Mining Research Center (TCMRC) and three projects by the Pittsburgh Technical Support Center (PTS). The majority of these projects (12 of 17) involved investigations of factors related to dust-make and dust control, both of which are among the more important areas for research.

Seventeen projects were found to be funded by governmental agencies other than the Bureau of Mines. The majority (14) of these projects were funded by NIOSH, two by the Commonwealth of Pennsylvania, and one "in-house" project conducted by NIOSH. Nine of these sixteen projects involved dust measurement instrumentation based upon gravimetric and photometric principles. The industry believes the research projects indicate serious questions on the accuracy and reliability of present instruments. The industry believes that the mere number of laboratory-type projects devoted to the personal samplers in itself indicates an official concern for the accuracy of the present instruments.

Twenty-three projects funded by the Bureau of Mines were conducted by external organizations. These projects cover the following areas: (1) sampling instrumentation, (2) machine design, (3) dust control, (4) dust physics, (5) mining technology, (6) respirable dust analysis, and (7) respiratory protection. Three projects were completed as of February 1, 1973. While research on dust sampling instrumentation is essential, such work should primarily be confined to a better understanding of the performance of the MRE and personal samplers and the resolution of factors responsible for the erratic performance of existing instruments.

8.

The funding of a study of the application of expansion foams for control of respirable dust and development of a vacuum system for dedusting ribs and floor would appear to warrant a low priority.

Research on the physics of dust needs continued effort but should concentrate on airborne dust as it actually exists in the mine atmosphere. Projects involved in investigating the electrostatic phenomena of polymer surfaces to dust precipitation and work on the adhesive forces of coal and rock dust to coal substrates are additional examples of research areas which should, in the opinion of the coal industry, be of low priority at this time.

2. Projects Conducted by Coal Producers: Present technology on machine sprays, the "wet head" machine, and the development of face ventilation practices have been largely industry developments. It was logical that the industry undertake applied research on the accuracy and reproducibility of present gravimetric instruments and refinements in the present dust control technology; details of 89 coal producer projects were given to demonstrate the type of research conducted.

Sixty-one of these projects related to dust control--face ventilation, sprays, water infusion, foam, and machine-mounted scrubbers. Six projects were conducted on sampling instrumentation, such as determining correlations between instruments contained in machine-mounted instrument packages and field testing newly-developed instruments. Eleven projects involved machine design, primarily wet head developments.

The individual producers feel that they do not have the manpower or resources to conduct effective research on optimizing systems for the suppression of respirable dust at their own miners. Most coal producers are, however, willing to provide the necessary field facilities to a qualified organization for extended applied research. It is consequently proposed that the Bureau fund the majority of their sponsored dust control projects with those coal producers and industry supported associations that have the capacity to organize the resources necessary for such applied research.

3. Technological Deficiencies: The technological deficiencies ascertained from each project are discussed in the Project Briefs prepared for each project and included in the Appendix.

The major technologic deficiencies for the major research projects are as follows:

a. Dust Sampling Instruments: Recent data on converting personal gravimetric sampler measurements to equivalent MRE values indicate that the present conversion factor may be invalid.

b. Scrubbers: The dust collection efficiency of machine-mounted scrubbers should be improved, particularly in the respirable dust range. Machine-mounted scrubbers may adversely affect the face ventilation flow pattern by recirculation. Scrubbers increase the noise hazard potential.

c. Sprays: While sprays mounted on mining machines constitute one of the earliest and most widely used type of control measures, further research is necessary to determine optimum configuration for sprays.

d. Ventilation: There is a need to update our present knowledge of ventilation especially to enable the development of more automatic, less hazardous equipment.

e. Wet Head Machine: This machine has considerable potential value, if the seal problem can be resolved.

f. Water Infusion: There is a need to review all available data on water infusion so as to evaluate how it may be more rapidly developed as an important method of dust suppression for certain coal beds.

III. INFORMATION SOURCES

The research needs of the industry were first presented to the Bureau at a meeting held September 23, 1970. This meeting was attended by the following persons:

1. Dr. James J. Scott, Assistant Director - Mining, USBM.
2. Mr. Bruce F. Grant, Research Mgr., Office of Deputy Director for Health and Safety, USBM.
3. Mr. William Poundstone, Consolidation Coal Company.
4. Mr. Woods Talman, Chief Inspector - Coal, U.S. Steel Corporation.
5. Mr. J. Moody, President, Bituminous Coal Operators' Association.
6. Mr. R. Vines, Safety Director, Bituminous Coal Operators' Association.

The data for Phase I of the report were obtained by conducting interviews, mostly by telephone, with the key personnel listed in Tables 1 and 2 of the Phase I report. As a result of the interviews the data in Tables 3, 4, 5, and 6 of the Phase I report were developed.

As a start in meeting the requirements of Phase II, the personal and telephone interviews described previously were conducted. The Bureau of Mines personnel interviewed are listed in Table 1, the personnel of other government agencies are listed in Table 2, and the personnel representing coal producers and equipment manufacturers are listed in Table 3.

A. Details of Personal Interviews

1. Interviews with Government Representatives: Visits were made to the NIOSH in Cincinnati, the Pittsburgh Mining and Safety Research Center (PM&SRC) laboratories in Bruceton, the Twin Cities Mining Research Center (TCMRC) laboratories in Twin Cities, and to the Pittsburgh Technical Service Center (PTS) in Pittsburgh. During these visits most of the significant dust measurement and dust control projects were discussed in sufficient detail to prepare draft "Project Briefs" on most of the projects conducted by or on behalf of government agencies.

A survey was also made of State agencies and universities to determine their involvement in other than federally-funded dust control research. The only projects sponsored by state governments were two by the Commonwealth of Pennsylvania.

2. Interviews with Industry Representatives: Visits were made to the area headquarters of coal producers in Southern Illinois, West Virginia, and Virginia. The views of key industry personnel were obtained on the subjects of dust measurement and dust suppression as required in the contract. During these interviews, data on all their current and recent unpublished research projects were also discussed in sufficient detail to prepare draft "Project Briefs."

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TABLE 1. LISTING OF KEY U.S. BUREAU OF MINES PERSONNEL INTERVIEWED
DURING INVENTORY OF RESEARCH ON DUST CONTROL

<u>Name</u>	<u>Position</u>	<u>Station</u>	<u>Date</u>	<u>Type¹</u>
Dr. Welby G. Courtney	Research Supervisor	PM&SRC	12/18/72	P
Dr. Richard Stein	Physicist	PM&SRC	12/18/72	P
Dr. John Breslin	Physicist	PM&SRC	12/18/72	P
Mr. Norman E. Hanna	Physical Science Administrator	PM&SRC	12/29/72	T
Mr. Kelly C. Strebbig	Head, Coal Fragmentation Studies	TCMRC	1/2, 3/73	P
Mr. Peter G. Chamberlain	Head, Rock Property Determination Research	TCMRC	1/2/73	P
Mr. Jacob N. Frank	Head, Hydraulic Fragmentation Research	TCMRC	1/2/73	P
Mr. H. William Zeller	Physical Scientist	TCMRC	1/2/73	P
Mr. Donald R. Kurth	Mathematician	TCMRC	1/2/73	P
Mr. Thomas F. Tomb	Acting Chief of the Dust Control Group	PTS	1/5/73	P
Mr. Robert Dalzell	Chief Ventilation Group	PTS	1/5/73	P
Dr. Mike Zabetakis	Research Supervisor	PM&SRC	1/15/73	T
Mr. Maurice Deul	Supervisory Geologist	PM&SRC	2/5/73	P

¹ P - Personal Interview
T - Telephone Interview

TABLE 2. LISTING OF OTHER KEY GOVERNMENT PERSONNEL INTERVIEWED
DURING INVENTORY OF RESEARCH ON DUST CONTROL

<u>Name</u>	<u>Position</u>	<u>Organization</u>	<u>Date</u>	<u>Type¹</u>
Dr. David Maneval ²	Science Advisor	Appalachian Regional Commission	11/30/72	T
Dr. George A. Carson	Chief, Particulate Air Sampling Section	NIOSH Cincinnati	12/12/72	P
Mr. Alan K. Gudeman	Chief, Control Research Section	NIOSH Cincinnati	12/12/72	P
Mr. Joseph Leonard	Director	West Virginia Coal Research Bureau	12/15/72	T
Mr. Jack A. Simon	Head, Coal Division (Emeritus)	Illinois Geological Survey	12/15/72	T
Dr. J. Richard Lucas	Head, Division of Mineral, Engineering	Virginia Polytechnic Institute	12/19/72	T
Mr. Phillip Zullo	Industrial Hygienist	Pennsylvania Bureau of Occupational Health	12/27/72	T
Dr. William Moroz	Director, Center for Air Environment Studies	Pennsylvania State University	2/9/73	T
Mr. Richard Lester	Project Officer	NIOSH Cincinnati	2/12/73	T
Mr. Thomas Anania	Chief, Industrial Hygiene Services	NIOSH Cincinnati	2/21/73	T

¹ P - Personal Interview

T - Telephone Interview

² Former Director Pennsylvania Coal Research Board

TABLE 3. LISTING OF KEY COAL INDUSTRY PERSONNEL INTERVIEWED
DURING SURVEY OF DUST CONTROL RESEARCH

Name	Position	Company	Date	Type ¹
Dr. John Campbell	Project Engineer	Peabody Coal Co. Ledgement Laboratory	11/21/72	P
Mr. Fred Stedman	Manager, Mining Products	Donaldson Co., Inc.	1/3/73	P
Mr. Thomas Rosendahl	Senior Project Engineer	Donaldson Co., Inc.	1/3/73	P
Dr. Douglas Dahl	Director of Mining Research	Continental Oil Co.	1/4/73	T
Dr. Ted F. Gundlach	General Manager	T. J. Gundlach Machine Co.	1/8/73	P
Mr. Ford Bain	Assistant General Manager	Old Ben Coal Corp.	1/9/73	P
Mr. Phillip Bailie	Project Engineer	Old Ben Coal Corp.	1/9/73	P
Mr. Milford Harrel	Vice President, Operations	Freeman Coal Corp.	1/9/73	P
Mr. Paul Budzak	Safety Director	Freeman Coal Corp.	1/9/73	P
Mr. Frank Padavic	Production Engineer	Freeman Coal Corp.	1/9/73	P
Mr. Norman Kutzing	Maintenance Superintendent	Freeman Coal Corp.	1/9/73	P
Mr. Frank Dillard	Chief Engineer	Ziegler Coal Corp.	1/10/73	P
Mr. Ralph Banks	Safety Director	Inland Steel Corp.	1/10/73	P

¹P - Personal Interview
T - Telephone Interview

TABLE 3. LISTING OF KEY COAL INDUSTRY PERSONNEL INTERVIEWED
DURING SURVEY OF DUST CONTROL RESEARCH (Continued)

<u>Name</u>	<u>Position</u>	<u>Company</u>	<u>Date</u>	<u>Type¹</u>
Mr. Joseph Craggs	Vice President	Peabody Coal Corp.	1/11/73	P
Mr. Ray C. Whitlow	Assistant General Superintendent	Peabody Coal Corp.	1/11/73	P
Mr. Paul Lingo	Employee Relations Manager	Monterey Coal Co.	1/11/73	P
Mr. Thomas Steele	Safety Engineer	Monterey Coal Co.	1/11/73	P
Dr. George Andria	Consulting Statistician	Bituminous Coal Research	1/17/73	P
Mr. Kenneth Whitehead	Project Engineer	Bituminous Coal Research	1/18/73	P
Mr. Frank Stevens	Project Engineer	Bituminous Coal Research	1/19/73	P
Mr. Charles Jesse	Production Manager	Westmoreland Coal Corp.	1/23/73	P
Mr. R. H. Hamrick	Director, Occupational Health & Safety	Westmoreland Coal Corp.	1/23/73	P
Mr. Joseph Bledsoe	Environmental Engineer	Westmoreland Coal Corp. Stonega Division	1/23/73	P
Mr. Paul Kade	Environmental Engineer	Westmoreland Coal Corp. Winding Gulf Division	1/23/73	P
Mr. Connie Chewning	Environmental Engineer	Westmoreland Coal Corp. Hampton Division	1/23/73	P

¹ P - Personal Interview
T - Telephone Interview

TABLE 3. LISTING OF KEY COAL INDUSTRY PERSONNEL INTERVIEWED
DURING SURVEY OF DUST CONTROL RESEARCH (Continued)

Name	Position	Company	Date	Type ¹
Mr. Robert Ryland	Chief Engineer	Clinchfield Coal Co.	1/23/73	P
Mr. James Fleming	Safety Engineer	Clinchfield Coal Co.	1/23/73	P
Mr. J. L. Adkins	Director of Safety	Island Creek Coal Co. Island Creek Division	1/24/73	P
Mr. Kenneth Morse	Director of Environmental Health	U.S. Steel	1/26/73	P
Mr. Thomas Kobrick	Director of Mine Inspection	Bethlehem Mines	1/29/73	P
Mr. Edward Onuscheck	Chief Mine Inspector	Rochester & Pittsburgh Coal Co.	1/29/73	P
Mr. William Poundstone	Executive Vice President	Consolidation Coal Co.	2/1/73	T
Mr. C. Eugene Linkous	Corporate Manager of Safety	Island Creek Coal Co.	2/2/73	T
Mr. William Laird	Vice President, Research	Eastern Associated Coal Corp.	2/9/73	T
Mr. Roy Agin	Chief Engineer, Face Equipment	Jeffrey Mining Machine Company	2/15/73	P
Mr. Ralph Hiltz	Senior Scientist	MSA Research	2/16/73	T

¹ P - Personal Interview

T - Telephone Interview

TABLE 3. LISTING OF KEY COAL INDUSTRY PERSONNEL INTERVIEWED
DURING SURVEY OF DUST CONTROL RESEARCH (Continued)

Name	Position	Company	Date	Type ¹
Mr. H. Eugene Mauck	Assistant Manager of Mines Mountaineer Division	Consolidation Coal Co.	2/21/73	T
Mr. Robert P. Aikman	Section Manager, Coal and Coke Research	Bethlehem Steel Corp.	2/26/73	T
Mr. William Goddard	Vice President, Central Division	North American Coal Co.	2/26/73	T

¹ P - Personal Interview
T - Telephone Interview

18.

After the visits to Illinois, Virginia, and West Virginia, interviews were conducted with key personnel of operators with mines closer to the Pittsburgh area. During these later interviews, the principal emphasis was on unusual projects since it appeared that most companies and divisions of larger companies, had all investigated the application of the basic tools of dust control to their specific needs and the application of scrubbers.

Interviews with representatives of equipment manufacturers were not required in the contract. However, during the visits, interviews were conducted with key personnel of the Donaldson Company, Gundlach Machine Company, and the Jeffrey Mining Machine Company. During these interviews, data for "Project Briefs" were also collected.

IV. NATURE AND BASIS OF INDUSTRY VIEWS

The nature and basis of industry views on the accuracy of our present respirable dust sampling instruments and the needs for improvement of our present dust control technology are herein presented. Dust production is inherent in all methods of mining but must be reduced to within safe levels if the incidence of coal worker's pneumoconiosis is to be reduced and finally eliminated. The achievement of this objective requires reasonably accurate instruments for dust measurements and practical and effective dust control measures. Finally, any program which is developed to measure and control dust must consider its economic impact upon the industry. If the downward trends in productivity, which developed with the enactment of P.L. 91-173, are not soon reversed by the development of improved mining techniques or a more reasonable administration of the Act, all present forecasts for the use of coal in the economy may become invalid.

A. Respirable Dust Sampling Instrumentation

The Bureau selection of the "personal sampler" principle of dust measurement is basically sound. However, extensive use of gravimetric instruments, by the industry and others, has demonstrated that the development of an accurate, reliable instrument, whose performance is highly reproducible, presents more problems than initially anticipated. Considerably more research must be undertaken to identify and remedy several factors that have made present measurements of respirable dust uncertain. The industry further believes that gravimetric measurements of respirable dust are the best index of dust hazard. The instrumentation was not adequately evaluated under American mining conditions to provide sufficient experience for optimum use nor were sufficient data obtained to support the conversion factor now used to determine MRE equivalent values.

A recent study conducted by a group of coal producers, was undertaken to determine the accuracy and reproducibility of two makes of gravimetric instruments by sampling with paired instruments in packages mounted on mining machines and in return airways. The data evaluation not only demonstrated erratic instrument performance by both makes of personal samplers but also a lack of correlation between them and the MRE unit. The data confirm the findings of the Triangle Research Report, funded by NIOSH.

The industry believes that numerous factors may contribute to this instrument problem when they are used in a mine. Some of these factors are:

1. Instrument orientation in the ventilation stream.
2. Moisture and water droplets.
3. Coarse dust in occasional dense clouds that envelop the instrument.
4. Rock dusting in vicinity of sampler.
5. Turbulence of the dust-laden air stream around the sampling instrument.
6. Poor control of preweighing of cassettes by the supplier and errors in weighing filters after use.
7. Loss of filter material by air stream.
8. Dust pick-up from clothing of miner.

It is the opinion of the industry dust research personnel that research is required to identify the major factors responsible for the inconsistent instrument performance and to develop recommendations for modifications in the design and/or use of the instrument to enable consistent performance. One design change which it believes merits attention is the development of a simple constant flow device to insure a uniform sampling rate throughout the full 8-hour shift.

B. Dust Suppression and Control

The coal industry has reduced airborne dust in underground coal mines by optimizing the number of water sprays and by making alterations in the face ventilation so that the high-risk occupations are located as much as possible in the uncontaminated air stream. While many mines are relatively unrestricted in the use of water except for poor floor conditions, mines which convey raw coal directly to steam-power generating plants cannot deliver a saturated product. These mines must rely primarily upon ventilation for dust control, with less than optimum water use.

Through optimization of ventilation and use of water sprays, together with good training of machine operators in minimizing dust generation, many mines were able to achieve continuous compliance with the 3.0 mg/m³ standard. Mine operators are concerned about their ability to consistently comply with the 2.0 mg/m³ standard. The operators feel that new developments in mining technology are required to enable realistic compliance with this dust standard.

The coal industry has always made a major contribution to the technology of dust control. Our present technology on machine sprays, the "wet head" machine, and the development of new face ventilation practices have been largely industry developments. Therefore, it was logical that the industry undertake applied research projects on the present dust control technology. The industry feels, however, that considerably more research is required before such concepts as "wet head" machines, scrubbers, and water infusion can be realistically evaluated and reduced to practice. The industry is of the opinion that it constitutes the best source for extensive field investigations. Consequently, it is of the opinion that programs should be developed by the Bureau to fund research projects with those coal producers or industry-supported associations having the investigative and staff competency to undertake such research.

C. Other Views of the Industry

The coal industry is of the opinion that any pneumoconiosis prevention program must be based upon knowledge of how much dust causes this respiratory disease and what mine conditions should be maintained to prevent disablement among miners. Therefore, any dust sampling instrument must be correlated with pulmonary response of the miners and with mine conditions and coal seams in American mines. Such biological correlations were done initially with the MRE, and earlier data collected with thermal precipitators were later converted to MRE equivalent readings by the National Coal Board. However, this study was limited to the miners, and to mines in England engaged in longwall mining. Dust sampling in American mines is conducted with the

personal gravimetric sampler; and, although the Bureau has indicated that they can convert these measurements into MRE equivalent values, this does not imply biological correlation for the personal sampler since its performance in collecting respirable dust is not identical with that of the MRE.

The coal producers feel that the Bureau (and NIOSH) should support epidemiological studies of miners, particularly the young miners who entered the industry after enactment of P.L. 91-173. It is felt that this group will most readily provide the answer to the adequacy or inadequacy of dust standards.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

V. EVALUATION OF RESEARCH PROJECTS - GOVERNMENT AND INDUSTRY

Research activities undertaken both by governmental agencies, or funded by them, and those conducted by coal producers and mining equipment manufacturers were evaluated. The 146 projects reviewed have been classified by type and performing agency, as shown in Table 4. The classification established for categorizing each project was developed by the Contractor after reviewing the objective of the work and discussing it with the performing agency or company. Some projects could be classified into one of several categories; however, only one category was selected for each project. For example, research involving the wet head mining machine could be classified as a dust control project; however, it was classed as a machine design project since it related to a major alteration in the design of the mining machine.

Table 4 indicates a wide distribution of the types of research projects. Of the total number of projects, 112 (76.7 percent) covered three categories, namely, sampling instrumentation, dust control, and machine design. The preponderance of dust control projects was due largely to the emphasis coal producers have given to this activity as it relates to compliance with the dust standards of P.L. 91-173.

A. Government-funded Research

This category includes (1) research carried on by the Bureau as "in-house" projects; (2) research funded by the Bureau but conducted by outside contractors; and (3) research funded, or conducted by, other government agencies, primarily the National Institute of Occupational Safety and Health (NIOSH). Table 5 lists the 17 projects conducted "in-house" by the Bureau. Table 6 lists the 23 projects funded by the Bureau and conducted by outside contractors. Table 7 lists the 17 projects conducted by, or funded by, other governmental agencies. NIOSH was the principal agency funding the research in this category, as indicated by its support of 11 of the 17 projects. Only one NIOSH project was conducted as an "in-house" activity.

The type of research conducted by both the Bureau and NIOSH reflected their responsibilities under P.L. 91-173. The Bureau has the responsibility for (1) determining the degree of industry compliance with the dust standards; (2) establishing techniques and procedures for obtaining accurate dust samples; (3) establishing and approving dust control requirements; and (4) approval of dust sampling devices for intrinsic safety. NIOSH has the responsibility for approving design and performance of respirable dust sampling instruments and approval of respiratory protective devices.

1. Respirable Dust Sampling Instrumentation: Unless accurate respirable dust sampling instrumentation is available, any program for the control and prevention of coal workers' pneumoconiosis, which is the objective of P.L. 91-173, will be materially affected. Research on instrumentation can result in appreciable costs; therefore, the immediate research needs should be determined from those problems related to the administration of the Act. For example, the Bureau has established the personal sampler (PS) as the instrument for determining compliance with the dust standards. A conversion factor for

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TABLE 4. TYPE OF PROJECTS AND PERFORMING AGENCY

<u>Agency Conducting Research</u>	<u>Technology Category of Research Project</u>				
	<u>Total Projects</u>	<u>Sampling Instrumentation</u>	<u>Dust Control</u>	<u>Dust Physics</u>	<u>Dust Analysis</u>
Bureau of Mines (In-House)	17	1	5	5	1
Bureau of Mines (Funded)	23	4	6	5	2
Coal Producers and Machine Manufacturers	87	6	62	-	4
Other Governmental Agency Funded (Principally NIOSH)	17	8	3	1	-
TOTALS	146	19	76	11	7

<u>Agency Conducting Research</u>	<u>Technology Category of Research Project</u>				
	<u>Machine Design</u>	<u>Mining Technology</u>	<u>Respiratory Protection</u>	<u>Epidemiological Studies</u>	<u>Development of Research Facility</u>
Bureau of Mines (In-House)	2	3	-	-	-
Bureau of Mines (Funded)	4	1	1	-	-
Coal Producers and Machine Manufacturers	11	3	2	-	1
Other Governmental Agency Funded (Principally NIOSH)	-	-	4	1	-
TOTALS	17	7	7	1	1

TABLE 5. INVENTORY OF RESEARCH CONDUCTED "IN-HOUSE"
BY THE U.S. BUREAU OF MINES

<u>No.</u>	<u>Station</u>	<u>Project Title</u>	<u>Research Category¹</u>
1	PM&SRC	Dust Collector Technology	Dust Control Technology
2	PTS	Laboratory and Field Evaluation of Integral Machine-mounted Dust Collectors	Dust Control Technology
3	PTS	Methane Dilution Characteristics of Face Ventilation Systems Incorporating Integral Machine mounted Dust Collectors	Dust Control Technology
4	PM&SRC	Control of Respirable Dust by Water Infusion	Dust Control Technology
5	PM&SRC	Control of Respirable Dust by Stemming	Mining Technology
6	PM&SRC	Nature and Behavior of Mine Dust	Dust Physics
7	TCMRC	Reduction of Airborne Coal Dust by the Optimization of Continuous Mining Machine Parameters	Machine Design
8	TCMRC	Coal Dust Formation by Abrasion	Machine Design
9	TCMRC	Influence of Hydraulic Fragmentation of Coal on Dust and Noise Generation	Mining Technology
10	TCMRC	Research on Physical Properties of Coal and Coal Strata Rocks	Dust Physics
11	TCMRC	Fractography and Fracture Surface Mapping in Coal and Associated Rocks	Mining Technology

PM&SRC = Pittsburgh Mining and Safety Research Center
 PTS = Pittsburgh Technical Service Center
 TCMRC = Twin Cities Mining Research Center

¹ Assigned by Contractor

TABLE 5. INVENTORY OF RESEARCH CONDUCTED "IN-HOUSE"
BY THE U.S. BUREAU OF MINES (Continued)

<u>No.</u>	<u>Station</u>	<u>Project Title</u>	<u>Research Category¹</u>
12	PM&SRC	Dust Control At and Outby the Face	Dust Control Technology
13	TCMRC	Prediction of Coal Dust Generation by Mathematical Model	Dust Physics
14	PTS	Determining New Relationship Between MRE and Modified Personal Sampling Equipment	Dust Sampling Instrumentation
15	PM&SRC	Characterization of Mine Dust Particle	Dust Physics
16	PM&SRC	Aerodynamic Behavior of Mine Particles	Dust Physics
17	PM&SRC	Determination of Free Silica	Dust Analyses

PM&SRC = Pittsburgh Mining and Safety Research Center

PTS = Pittsburgh Technical Service Center

TCMRC = Twin Cities Mining Research Center

¹ Assigned by Contractor

TABLE 6. INVENTORY OF RESEARCH CONDUCTED BY GRANT OR CONTRACT
FROM U.S. BUREAU OF MINES

<u>No.</u>	<u>Organization Performing Research</u>	<u>Project Title</u>	<u>Research Category</u>
1	Apt, Bramer, Conrad & Associates	Engineering Methods Used to Control Respirable Dust in Underground Mines	Dust Control Technology
2	Ingersoll Rand Research	Design and Construction of Continuous Mining Machine	Machine Design
3	Clinchfield Coal Company	Environmental Dust Survey	Dust Control Technology
4	Monsanto Research Corporation	Foam Suppression of Respirable Coal Dust	Dust Control Technology
5	DeTer Company	Dust Suppression in Coal Mines (by Foam)	Dust Control Technology
6	Bituminous Coal Research, Inc.	Continuous Mining Machine Water Flushed Bits	Machine Design
7	Donaldson Company	Air Curtain Respiratory Protection Device	Respiratory Devices
8	Envirotech Corporation	Coal Mine Vacuum Sweeper	Dust Control Technology
9	Battelle Memorial Institute	Microminer Research Dust Generator	Machine Design

TABLE 6. INVENTORY OF RESEARCH CONDUCTED BY GRANT OR CONTRACT FROM U.S. BUREAU OF MINES (Continued)

No.	<u>Organization Performing Research</u>	<u>Project Title</u>	<u>Research Category</u>
10	Illinois Institute of Technology Research Institute	Coal Mining Using High Pressure Water Jets	Mining Technology
11	Bituminous Coal Research, Inc.	Study of Continuous Mining Machine Bit Technology	Machine Design
12	Lehigh University	Spontaneous Electrostatic Precipitation of Dust	Dust Physics
13	Syracuse University Research Institute	Investigation of Physics of Adhesion of Coal Aerosols	Dust Physics
14	Brown University	Acoustic Separation Process	Dust Control Technology
15	CERCHAR	Develop a Personal Dust Sampler	Dust Sampling Instrumentation
16	Stanford Research Institute	Portable Mine Dust Concentration Instrument	Dust Sampling Instrumentation
17	University of Minnesota	Research to Develop Instruments and Techniques for Making Dynamic Measurements of Coal Dust During Experimental Cutting Tests	Dust Sampling Instrumentation
18	University of Pittsburgh	Penetration Characteristics of a 10 mm Nylon Cyclone	Dust Sampling Instrumentation
19	Lehigh University	Fluid Dynamics of Small Particle Transport and Deposit	Dust Physics



TABLE 6. INVENTORY OF RESEARCH CONDUCTED BY GRANT OR CONTRACT
FROM U.S. BUREAU OF MINES (Continued)

No.	Organization Performing Research	Project Title	Research Category
20	Mine Safety Appliances	Development of a Simple, Rapid Analysis Method for Respirable Dust	Dust Analyses
21	Virginia Polytechnic Institute	Preparation of Pure and Impurity Stabilized Poly- morphs of SiO ₂	Dust Analyses
22	University of Pittsburgh	Physical and Chemical Characterization of Respir- able Coal Mine Dust	Dust Physics
23	Pennsylvania State University	Method for Quantitative Characterization of Coal Mine Dust	Dust Physics

TABLE 7. INVENTORY OF RESEARCH CONDUCTED BY GOVERNMENT ORGANIZATIONS
OTHER THAN U.S. BUREAU OF MINES

<u>No.</u>	<u>Organization Performing Research</u>	<u>Project Title</u>	<u>Research Category</u>
1	MSA Research ¹	The Development of High Expansion Foam System for the Suppression of Respirable Dust	Dust Control Technology
2	MSA Research ¹	The Development of High Expansion Foam for the Suppression of Respirable Coal Dust	Dust Control Technology
3	Commonwealth of Pennsylvania ²	Coal Handlers' Study	Epidemiological Study
4	Eastern Associated Coal Corp. ²	To Evaluate Current Respirator Use in Underground Coal Mines	Respiratory Devices
5	Synsis Inc. ²	Performance Evaluation of Air Supplied Respirators for Underground Coal Mining	Respiratory Devices
6	Atomic Energy Commission - LASL ³	Studies by LASL	Dust Control Technology
7	Webb Associates ²	Anthropological Research Related to Sizing and Fit of Respirators	Respiratory Devices
8	Synsis Inc. ²	Study to Develop a Prototype Air-supplied Respirator for Use by Underground Coal Mining Equipment Operators	Respiratory Devices

¹ Funded by Commonwealth of Pennsylvania

² Funded by Department of HEW (NIOSH)

³ Los Alamos Scientific Laboratory

TABLE 7. INVENTORY OF RESEARCH CONDUCTED BY GOVERNMENT ORGANIZATION
OTHER THAN U.S. BUREAU OF MINES (Continued)

No.	Organization Performing Research	Project Title	Research Category
9	University of Minnesota ²	Evaluation of a Coal Mine Dust Personal Sampler Performance	Dust Sampling Instrumentation
10	Bendix Corporation ²	Development of Improved Coal Mine Dust Sampler	Dust Sampling Instrumentation
11	Dynadyne Corporation ²	Intermediate Volume Personal Sampler	Dust Sampling Instrumentation
12	Pennsylvania State University ¹	Develop Portable Particulate Counting Machine	Dust Sampling Instrumentation
13	GCA Corporation ²	Coal Mine Dust Instantaneous Mass Monitor	Dust Sampling Instrumentation
14	New York University ²	Cyclone Performance Evaluation	Dust Sampling Instrumentation
15	New York University ²	Coal Mine Dust Mass Distribution Study	Dust Physics
16	Atomic Energy Commission (LASL) ³	Aerosol Studies and Sampler Development	Dust Sampling Instrumentation
17	NIOSH	Evaluation of Instruments to Measure Concentration of Respirable Coal Dust	Dust Sampling Instrumentation

¹ Funded by Commonwealth of Pennsylvania

² Funded by Department of HEW (NIOSH)

³ Los Alamos Scientific Laboratory

determining MRE equivalent values has been established. Early in the program, when the 3.0 mg/m^3 standard was in effect, the need for validation of this conversion factor, while a matter of major interest, was not as acute as the situation since the 2.0 mg/m^3 standard became effective. Therefore, it would appear that research on the MRE/PS conversion factor should be given a high priority together with research to determine those factors in the mine environment, during use of the personal sampler, which may adversely affect the performance of dust sampling instruments.

Thirteen projects involved instruments; eight were in developing new instruments, and five involved testing and/or evaluating the present gravimetric personal samplers. Projects 6-15 and 7-11 (No. 15-Table 6 and No. 11-Table 7) were projects on the development of high volume sampling instruments. Projects 6-15, 16-17, and 7-12 involved the development of an instantaneous mass monitor. Project 7-15 covered the development of an instrument to measure the mass distribution of dust over various size fractions. Project 7-10 covers a modified personal sampler with lapel-mounted filter-pump unit. Projects 5-14, 6-18 and 7-9, 7-14, and 7-17 involved evaluating present instruments or the elutriator thereof. Project 6-17 involves the development of an instrument with a trailer-mounted data processing unit intended to allow evaluations of short-term tests during the various phases of mining machine operation. While of interest, this would appear to be an instrument for use principally for researching dust generation during phases of the mining cycle.

While the number of research projects relating to sampling instruments does not appear to be excessive, there does appear to be a question whether or not new instrument development should have priority over the need for performance data on existing approved instruments under actual or simulated mining conditions. High volume respirable dust samplers are desirable to allow the collection of sufficient dust during a full-shift so as to improve the accuracy of analytical procedures for free silica and other constituents. Today, due to the very low mass in the total sample of respirable dust, an accuracy of 20 to 30 percent is common.

The value of instantaneous mass or particle counters, at this point in time, is questioned, although their eventual development may be desired. While mass is one of the principal parameters of the dust concentration, which is related to coal workers' pneumoconiosis, the mass of principal interest appears to be that inhaled over a span of years and not an instantaneous mass concentration. Furthermore, instantaneous monitors, whether of the mass or particle count (light-scattering) types, are of somewhat limited value as they tend to respond not only to dust but also to other particulates, such as water mist or oil fumes or mists.

There is the need for an instrument which can "size" the airborne dust in the mine into various size fractions as it exists in the mine atmosphere. It does not appear that this need has been resolved.

At present, there is considerable difference of opinion on the performance of, and evaluation of data from, approved gravimetric instruments. One concern about the instrument research projects listed in this report is that they are limited largely to laboratory study. While this area of study is

essential, it is at most only the first phase of determining acceptable instrument performance. An instrument, or element thereof, such as the elutriator, must demonstrate accuracy and reproducibility of performance in the environment in which it must measure respirable dust in underground coal mines. It is this environment in which it must be evaluated and not that in the laboratory dust chamber. Another need is for field research conducted by an agency thoroughly familiar with the manner in which an instrument will be used in the mine. For example, a personal sampler will be worn by a miner with its vertical position orientation under frequent change. In addition, the need for frequent air flow calibration must be appreciated as well as the cyclone inlet orientation. Therefore, it is felt that field testing of instruments should be undertaken by contractors having direct or indirect avenues for industry participation.

The projects which the contractor views as the most applicable to present needs are the following:

5-14
6-15, 6-17
7-9, 7-10, 7-11, 7-15, 7-17

Project 5-14, conducted by the PTS, is an in-mine study whose objective is the development of a new conversion factor for the "snubbed" sampler. Project 6-15 covers a high-volume sampler, and 6-17 involves a system of dynamic measurements of dust during short-term periods. Project 7-9 covers the evaluation of factors relating to instrument performance, 7-10 covers a modified filter-pump lapel-mounted sampler, 7-11 involves a high volume sampler, 7-15 covers a mass distribution instrument, and 7-17, an evaluation of present approved instruments.

2. Dust Physics: The scope of research in this category covers the generation, nature, and behavior of coal mine dust. This type of research is important to the design of sampling instruments, dust control objectives and requirements, and the hazardous component of the total airborne dust.

Eleven projects have been classified in this category and are shown in Tables 5, 6, and 7. Five of these projects are conducted in-house by the Bureau at its PM&SRC, and TCMRC facilities. It is felt that this type of research is basic to the objectives of P.L. 91-173. The only comment indicated from our evaluation is that projects in this research area must be judiciously selected to insure against excessive duplication of effort. Considerable work in this area has been done in this country, England, and Germany. One of the needs in this type of work is to compare American conditions with those of other nations which would involve similar techniques. Additionally, such research should reflect dust as generated in the mine and not redispersed from collected dust or crushed coal, insofar as this is practical.

In the Contractor's opinion, Projects 6-12 and 6-19 have minor practical value at this time. Projects 5-6, 5-10, 5-13, 5-15, and 5-16, however, have major value in developing an improved understanding of the process of fracturing coal with minimal dust generation.

Projects 5-7 and 5-8 and Projects 6-9 and 6-11 have been classified under the Machine Design category as they involve alterations in machine design. They could be classified as dust physics projects and would be considered as meriting a high priority rating.

3. Dust Control Technology: The development of an effective and practical dust control technology is the most important area for research, followed closely by the development of accurate respirable dust sampling instrumentation. These are the most important areas if the industry is to meet the present dust control standards. This contract indicates Bureau recognition of the significance to the coal producers of these research areas, in which there are major voids in our technology.

This category involves not only the optimization of the dust control measures in our present technology but, equally important, the advancement of this technology to allow coal producers to consistently meet the dust standards in an economical and practical manner. In the control of airborne contaminants, optimum control is achieved by process alterations or design which will reduce the development and generation of the contaminant and/or the design of a contaminant control ventilation system located close to the source of contaminant generation. Admittedly, these are not readily available at this time. The problem is somewhat complicated by the presence of two major air contaminants in underground coal mines, dust and gas, the control of which is not accomplished most effectively by the same type of face ventilation system. For example, it is generally agreed that methane emissions from the coal face are best controlled by a blowing system of ventilation since air can be blown for a considerably greater distance than it can be pulled or exhausted, with equal dilution effect. On the other hand, the dilution method of airborne dust control is generally not as effective a measure as that achieved by a localized exhaust system (i.e. curtain or tube) and would require much larger air volumes than an exhaust system. However, a blowing system could possibly be the preferred control method, if the quantity of dust generated and dispersed in cutting the face could be drastically reduced.

Our present dust control technology includes the simultaneous application of the following measures in addition to ventilation, which is a control measure in itself. These measures are listed in decreasing order of effectiveness in the control of respirable and float dust: (1) "wet head" machine, (2) sprays, (3) machine-mounted scrubber, (4) machine design, (5) water infusion, (6) foam, and (7) wetting agents. However, it is questionable whether these measures can be listed in this manner as Numbers 1 through 4 are complementary measures in the development of an optimum dust control system. For example, the "wet head" machine should reduce the dust load which the ventilation system must control; and, to a lesser degree, water spray would have a similar effect. On the other hand, ventilation is required for gas control and to control the dust generated for the "wet head" machine. Ventilation is the sole control measure which acts to control both dust and gas. The objective is to maximize these four elements into the most efficient control system. Item No. 4 envisions the design of a single integrated control system originally designed not only for cutting coal but to do so with the desired dust and gas control, by properly integrating the interplay of drum speed, bit design, bit lacing, water flushing, the use of scrubbers--a research area which has for too long received inadequate attention. Water infusion has been rated No. 6 because there has not been sufficient development of the parameters of this technology.

TABLE 8. EVALUATION OF PRACTICAL SYSTEM FOR DUST SUPPRESSION AT THE FACE

<u>System of Dust Suppression</u>	<u>Advantages</u>	<u>Disadvantages</u>	<u>Technological Deficiencies</u>
Sprays and ventilation	Uses available techniques. Best results if blowing and exhausting (Gas & Dust).	Too many variables, less effective with narrow rooms and blowing ventilation.	Questionable if higher rate of mining desired. Most improvement already made.
Wetting agents and ventilation	Limited to those coals which may be easily wetted and best applied to conveyor systems.	Application is highly limited.	Is not considered a major control measure.
Water flushed bits and ventilation (wet-head machine)	Potentially single system solution.	Requires more complex head for miner. Clear water. Improved nozzle, high pressure.	Work required to develop seals for effective and long term applications.
Miner-mounted scrubber with ducting and ventilation	Potentially single system solution.	Noisy, requires added equipment packed into mining machine. Problem of increased maintenance.	Scrubber needs to have longevity proven. Serious problem in ventilation especially where recirculation needed for performance.

Note is made that the "wet head" machine is indicated as a control measure, however, it probably represents the only significant breakthrough in machine design technology in this country, since the advent of the continuous miner. Although it has long been developed for longwall machines in England. A general evaluation of these control measures is indicated in Table 8.

Fifteen projects were classified in this dust control category, although seven machine design projects could also be so classified. This represents only 25.9 percent (38 percent, if seven machine design projects are included) of the total government-supported or conducted projects. It is felt that this is too small a distribution of research effort in view of the high priority of need for an improved dust control technology. However, while research effort in this category is inadequate, several projects have major importance to the coal industry. Projects 5-1, 5-2, 5-3, 5-4, and 5-12, which are Bureau "in-house" projects, have major practical significance to the industry. Similarly, some of the Bureau-funded projects have been well selected to meet some of the most practical avenues to improve our existing technology. Projects 6-2, 6-3, 6-6, 6-9, and 6-11 are in this category.

On the other hand, large funds to support research on projects of limited value, or the technology of which is already known, are highly questionable. For example, Project 6-1 involves \$50,000 for information that could be readily prepared by dust control engineers from the industry instead of by a contractor with few previous coal industry contacts. Projects 6-4 and 6-5 represent \$122,000 and \$329,000 expenditures for evaluating foam, the technology of which does not appear to have a high dust control value and has been previously researched at considerable expense. Project 6-8 involves a \$484,000 expenditure for a vacuum cleaner. It is believed that this appropriation could be better utilized in other research efforts of far greater industry need. The results indicated in Project 6-14 could have been foreseen by one knowledgeable in general dust control principles and the coal mine environment without an \$83,000 cost. The two foam projects, No. 7-1 and 7-2, are sponsored by the State of Pennsylvania and NIOSH, respectively. The Contractor feels these projects place a disproportionate amount of effort and money on a control measure which, to-date, has not been successfully demonstrated.

4. Machine Design Technology: Seventeen projects are in this category. They are all Bureau in-house or Bureau funded. It is felt that considerably greater effort must be directed in this area of research if major necessary improvements in our knowledge of dust generation and dispersion are to be developed. This information is basic to implementing the design of present mining machines or in developing new coal mining concepts. It is felt that all the projects--5-7, 5-8, 6-2, 6-6, 6-9, and 6-11--have been well selected.

There is need, however, to develop within the mining machine manufacturers a greater initiative in machine design research. Unfortunately, such research is extremely expensive. Possibly some joint Bureau-machine manufacturer funding of research could be developed. This work must consider the problems in low and high coal separately and should include investigating machine automation, particularly for low coal.

5. Respiratory Protective Devices: Five projects, chiefly NIOSH funded, are in this category. Project 6-7, which is Bureau funded at \$106,000, is

highly questionable. Coal operators are required to meet the dust standard, and in such an atmosphere respiratory protection is not necessary. Furthermore, it is believed that the miner would object to the daily wearing of another device with its additional weight. Projects 7-4, 7-5, 7-7, and 7-8 are NIOSH funded and involve a total expenditure of \$413,000. The same evaluation can be advanced for these projects as for the one which is Bureau funded.

6. Epidemiological Study: Only one project is in this highly important research category. This is a NIOSH funded project conducted by the State of Pennsylvania to study the prevalence of pneumoconiosis among coal handlers. It is believed that a well-organized study of young coal miners, employed during the past three years, should be undertaken to determine whether or not present dust standards are excessive or inadequate, and to endeavor to establish biological correlation of approved gravimetric dust samplers with the incidence of this disease. This should be a NIOSH-USBM study guided by an advisory committee having industry, medical, and industrial hygiene participation.

B. Research Conducted by Coal Producers

A total of 89 projects were included in this survey. These projects are listed in Table 9, which shows company or association involved and the classification assigned to the project. These were essentially "in-house" projects whose costs were solely funded by coal mine operators and equipment manufacturers. Cost estimates were obtainable on only 48 projects but it appears that many reasonable research costs were charged to operating budgets. However, the total cost for the 48 projects was \$2,278,000 which included \$651,000 for design and testing machine-mounted dust scrubbers; \$129,000 on "wet head" machines; \$464,000 on mining technology; and \$172,000 for the construction and development of a structure to simulate an underground heading. The latter structure was constructed at Bituminous Coal Research, Inc., and will be utilized for testing dust sampling instruments, ventilation systems, sprays, and other factors influencing accurate measurements of airborne dust and the improvement of our dust control technology.

The industry research projects were primarily involved in field testing dust sampling instrumentation, new dust control equipment or new concepts, design and testing changes in machines related to dust generation or control. Of the total 89 projects, 74 (83 percent) were conducted by 14 coal-producing companies, 11 by four equipment manufacturers, and four by the industry-supported association. The 24 projects on which cost data could be reliably estimated indicated that of the total expenditure of \$1,175,000, \$534,600 was derived from four equipment manufacturers and \$641,000 from 20 coal producing companies or divisions of large companies. These projects were principally short-term studies to determine the practicability or feasibility of new developments and procedures or modifications of existing practices involving dust control and dust sampling instrumentation. As indicated previously in Table 4, 60 percent of the total 89 projects covered dust control activities, 11 involved machine design and six covered the accuracy of dust sampling instrumentation. However, five of the projects in the machine design classifi-

TABLE 9. RESEARCH TITLES COLLECTED DURING SURVEY OF
COAL PRODUCERS AND EQUIPMENT MANUFACTURERS

No.	Company Performing Research	Project Title	Research Category
1	Peabody Coal Co., Ledgemont Laboratory	Model Study of Mine Ventilation	Dust Control Technology
2	Peabody Coal Co., Ledgemont Laboratory	Model Study of Face Area	Dust Control Technology
3	Peabody Coal Co., Ledgemont Laboratory	Test of Scrubbers	Dust Control Technology
4	Donaldson Co. Inc.	Development of Dust Separator for In-Mine Use	Dust Control Technology
5	Donaldson Co. Inc.	Development of System to Produce Respirable Exhaust	Dust Control Technology
6	Conoco	Underground Tests of Experimental Hydraulic Mining Equipment	Mining Technology
7	T. J. Gundlach Machine Co.	Development of 16 SC Scrubber	Dust Control Technology
8	T. J. Gundlach Machine Co.	Development of 22 SC Mini-scrubber	Dust Control Technology
9	T. J. Gundlach Machine Co.	Development of 30 SC Scrubber	Dust Control Technology
10	T. J. Gundlach Machine Co.	Development of Rose Valley Type of Scrubber	Dust Control Technology
11	Old Ben Coal Corp.	Test of Sprays and Development of Improved Spraying Systems for Mine Machines	Dust Control Technology

TABLE 9. RESEARCH TITLES COLLECTED DURING SURVEY OF
COAL PRODUCERS AND EQUIPMENT MANUFACTURERS (Continued)

<u>No.</u>	<u>Company Performing Research</u>	<u>Project Title</u>	<u>Research Category</u>
12	Old Ben Coal Corp.	Extended Underground Test of Deron Air Water Spray Systems for Dust Suppression on Mining Machines	Dust Control Technology
13	Old Ben Coal Corp.	Test of Low Resistance Exhaust Tubing	Dust Control Technology
14	Old Ben Coal Corp.	Belt Entry Clean Up	Dust Control Technology
15	Old Ben Coal Corp.	Test of Gundlach 22 SC Mini- scrubbers on Goodman Boring Machine	Dust Control Technology
16	Old Ben Coal Corp.	Test of Gundlach 30 SC Scrubber for Continuous Miner	Dust Control Technology
17	Old Ben Coal Corp.	Test of Scrubber Using Donaldson Panel Built into Jeffrey Contin- uous Miner	Dust Control Technology
18	Old Ben Coal Corp.	Economic Evaluation of the Use of Cryogenic Air Supply for Equipment Operators	Respiratory Protection
19	Freeman Coal Company	Test of Wetting Agents	Dust Control Technology
20	Freeman Coal Company	Test of Steam for Dust Suppression	Dust Control Technology
21	Freeman Coal Company	Test of Compressed Air and Water Mixture on Face Machines	Dust Control Technology

TABLE 9. RESEARCH TITLES COLLECTED DURING SURVEY OF
COAL PRODUCERS AND EQUIPMENT MANUFACTURERS (Continued)

<u>No.</u>	<u>Company Performing Research</u>	<u>Project Title</u>	<u>Research Category</u>
22	Freeman Coal Company	Test of Face Ventilation with Both Exhaust and Blowing Tubings	Dust Control Technology
23	Freeman Coal Company	Test of Foam for Dust Suppression	Dust Control Technology
24	Freeman Coal Company	Test of Miner Mounted Scrubbers	Dust Control Technology
25	Freeman Coal Company	Test of Wide Room Mining	Mining Technology
26	Freeman Coal Company	Evaluation of Dust Control Technology	Dust Control Technology
27	Ziegler Coal Company	Test of Miner Mounted Gundlach Scrubbers	Dust Control Technology
28	Ziegler Coal Company	Test of Factory Designed Scrubber Installed on a Jeffrey Heliminer	Dust Control Technology
29	Ziegler Coal Company	Comparison of Continuous Versus Conventional Mining	Mining Technology
30	Inland Steel	Extended Field Test of ENJAY 7-9607 Dust Suppression Agent Added to Spray Water	Dust Control Technology
31	Inland Steel	Test of Miner Mounted Scrubber with Blowing Face Ventilation	Dust Control Technology
32	Inland Steel	Evaluation of Exhaust Tubing	Dust Control Technology
33	Inland Steel	Side By Side Testing of MSA Personal Samplers	Sampling Instruments

TABLE 9. RESEARCH TITLES COLLECTED DURING SURVEY OF
COAL PRODUCERS AND EQUIPMENT MANUFACTURERS (Continued)

No.	Company Performing Research	Project Title	Research Category
46	Bituminous Coal Research, Inc.	Statistical Analysis of Respirable Dust Samplers	Sampling Instruments
47	Westmoreland Coal Company	Development of Spray Applications to Minimize Dust Emissions	Dust Control Technology
48	Westmoreland Coal Company	Test of Scrubber Mounted on Continuous Miner	Dust Control Technology
49	Clinchfield Coal Company	Experimental Tubing Exhaust System for Conventional Mining	Dust Control Technology
50	Clinchfield Coal Company	Modification of Wilcox Miner to Provide Clean Air for the Jack Setters	Dust Control Technology
51	Clinchfield Coal Company	Experiments in Water Infusion	Dust Control Technology
52	Clinchfield Coal Company	Development of Remote Control Equipment	Machine Design
53	Island Creek Coal Company Island Creek Division	Improved Sprays on Continuous Mining Machines	Dust Control Technology
54	Island Creek Coal Company Island Creek Division	Test of Wetting Agent in Spray Water	Dust Control Technology
55	Island Creek Coal Company Island Creek Division	Evaluation of Factors Affecting Dust Generation	Machine Design
56	Island Creek Coal Company Virginia Division	Simultaneous Development of Travelling Water Sprays and Use of Water Infusion for Dust Control	Dust Control Technology

TABLE 9. RESEARCH TITLES COLLECTED DURING SURVEY OF
COAL PRODUCERS AND EQUIPMENT MANUFACTURERS (Continued)

<u>No.</u>	<u>Company Performing Research</u>	<u>Project Title</u>	<u>Research Category</u>
57	U.S. Steel Corporation	Performance of Snubbered and Unsnubbered Samplers	Sampling Instruments
58	U.S. Steel Corporation	Accuracy of Manufacturer's Indicated Filter Cassette Weights	Dust Analysis
59	U.S. Steel Corporation	Cooperative Study with USBM to Determine Instrument Correlations Near Lee Norse 354 Machine	Sampling Instruments
60	U.S. Steel Corporation	Moisture Effect on Filters	Dust Analysis
61	U.S. Steel Corporation	Filter Tare Weight Variance	Dust Analysis
62	U.S. Steel Corporation	Comparison of Auxiliary Fan and Tubing with Line Curtain Methods of Face Ventilation with Lee-Norse Miner	Dust Control Technology
63	U.S. Steel Corporation	Water Applied to Cutting Edges of Lee-Norse Continuous Miner	Machine Design
64	U.S. Steel Corporation	Dust Suppression with Joy 8CM-Wet Head Continuous Miner	Machine Design
65	U.S. Steel Corporation	Dust Suppression with Jeffrey Heliminer Wet Head Continuous Mining Machine	Machine Design
66	U.S. Steel Corporation	Role of Machine Variables on Dust Concentrations with Boring Machines	Machine Design
67	U.S. Steel Corporation	Investigation of Cryogenic Air Supply	Respiratory Protection

TABLE 9. RESEARCH TITLES COLLECTED DURING SURVEY OF
COAL PRODUCERS AND EQUIPMENT MANUFACTURERS (Continued)

No.	Company Performing Research	Project Title	Research Category
68	U.S. Steel Corporation	Analytical Method for Quartz in Respirable Dust	Dust Analysis
69	Bethlehem Mines	Study of High Pressure Water and Air Atomizing Sprays	Dust Control Technology
70	Bethlehem Mines	Test of Simulated Miner Mounted Scrubber	Dust Control Technology
71	Bethlehem Mines	Test of Foam for Dust Suppression	Dust Control Technology
72	Bethlehem Steel Corporation	Long Term Face Operations Improvements	Machine Design
73	Consolidation Coal Research Division	Development of Improved Pick-up for Inlet to Scrubber Duct	Dust Control Technology
74	Consolidation Coal Mountaineer Division	In-Mine Testing of Strato-scrubbers Installed on Jeffrey Heli-miners	Dust Control Technology
75	Eastern Associated Coal Corporation	Calibration and Evaluation of GCA Respirable Dust Monitor	Sampling Instruments
76	Eastern Associated Coal Corporation	Test of Improved Filtering Techniques for Spray Lines	Dust Control Technology
77	Eastern Associated Coal Corporation	Test of Jeffrey Scrubber with Donaldson Panel	Dust Control Technology
78	Eastern Associated Coal Corporation	Test of Water Infusion for Dust Suppression	Dust Control Technology

TABLE 9. RESEARCH TITLES COLLECTED DURING SURVEY OF
 COAL PRODUCERS AND EQUIPMENT MANUFACTURERS (Concluded)

<u>No.</u>	<u>Company Performing Research</u>	<u>Project Title</u>	<u>Research Category</u>
88	Old Ben Coal Corporation	Test with Exhaust Fan Mounted on Goodman Miner	Dust Control Technology
89	Old Ben Coal Corporation	Test of Original Gundlach Scrubber for Ripper Type Continuous Miner	Dust Control Technology

cation covered "wet head" machines and could be classed in the dust control category, which would result in 77 percent of the total projects being involved in dust control.

1. Dust Control Technology: A review of the 62 projects in this category indicated that they were distributed in the following major classifications: dust scrubbers - 26 projects, water sprays and wetting agents - 14 projects, ventilation - 9 projects, foam - 5 projects, water infusion - 4 projects, miscellaneous - 4 projects. Of interest are the recent visitations made by two coal producers to the National Coal Board in England to observe their dust control research program and to visit coal mines. As stated previously, the present technology of dust control in underground bituminous coal mines is for the most part a development of the industry. This was achieved without any national dust standard prior to the enactment of P.L. 91-173; therefore, the control objective was to meet standards of the various states, where such existed, or recommendations of the Bureau. These standards were based totally upon particle count measurements. Obviously, with the present more restrictive federal dust standards, improvements in our dust control technology will be necessary, or a new technology must be developed. It is equally obvious from a review of the scope of the industry research effort that such changes are already under intense study.

Probably the major comments that can be advanced in evaluating the industry research effort are the following: (1) it is too individualistic in that each company carries on its research without dissemination of the data among other companies; and (2) there is duplication of projects, which results in overfunding in the same area of investigation. This situation is probably due to the competitive nature of the industry, but it would appear that some degree of combined effort would be beneficial to the entire industry.

2. Respirable Dust Sampling Instrumentation: The industry has been of the opinion, since the passage of P.L. 91-173, that accurate dust measurement instrumentation was not available and that the poor state-of-the-art of gravimetric dust sampling had not been understood by Congress in its deliberations. The industry, on an individual company basis, could not engage in such research immediately, as it had to concentrate all of its efforts on establishing its program to conform with the Bureau dust sampling regulations as well as to develop its dust control program. Nevertheless, a few companies did undertake instrument evaluation in field studies and the data demonstrated instrumental and human errors which indicated highly questionable accuracy in the field use of such instruments. This situation led to two research studies conducted as a joint company effort (Projects 9-43 and 9-46). Continued effort is necessary to determine those factors in the field use of gravimetric dust samplers which are responsible for their erratic behavior in sampling the mine atmosphere.

Four projects (9-58, 9-60, 9-61, and 9-68) involved investigations into several factors in the accurate weighing of the respirable dust on the filter paper and in the development of a method for determining the quartz content of the respirable dust. In the former problem area, the quality of the filter cassette manufacturers' control of the weighing process, the variation in the weight of filters of the same type, and the size effect of water droplets on

accurate weighing of the dust were investigated. It was concluded that the cassette manufacturers' quality control was poor and that moisture removal from the dust-laden filter was essential to obtain accurate weights. Today, there is need for an independent evaluation of the cassette manufacturers' quality control as related to accurate weighing, an evaluation of the entire Bureau program of processing submitted dust samples, and an evaluation of the manufacturers' control programs to insure accurate weighing.

3. Machine Design Technology: The "wet head" development in continuous mining machine design was an industry development. This application of water to the cutting bits was first researched in 1963 by one coal producer. Its work revealed a most significant reduction in respirable dust. Although the seal problem could not be adequately resolved, it installed at that time several "wet head" continuous miners as designed by two of the leading machine manufacturers. Interest in this type of machine is demonstrated by the fact that six of the 11 research projects in the machine design category involved this type of machine (Projects 9-63, 9-64, 9-65, 9-80, 9-83, and 9-84).

4. Mining Technology: Investigation into methods of coal extraction should be under continuous study. However, the motivation for such research should not only be one of reducing the respirable dust and other hazards but also the economics of mining coal. Mining costs have increased considerably since the passage of P.L. 91-173, and many coal producers have had no alternative but to close their mines. The coal industry engaged in three projects in this area; one of these projects (9-6) involved hydraulic mining, the other two (9-52 and 9-72) were in the area of machine automation.

Of major interest are two projects which involved research in the area of automating the operation of the continuous miner, the objective being the removal of miners from the high risk operations. It would appear that an expanded program in this area should be undertaken, largely funded by the Bureau and machine manufacturers.

5. Respiratory Protective Devices: Two projects (9-18 and 9-67) involved cryogenic respiratory equipment for machine operators at the face. One project (9-18) covered the economic evaluation of such a respiratory device, while the other (9-67) involved its initial development. Although this type of equipment provides full protection for the continuous mining machine and shuttle car operators, and was acceptable to these operators since it did not require wearing a belt pack, the dust standard in P.L. 91-173 appears to inhibit its daily use.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

VI. SUMMARY OF RESEARCH DEFICIENCIES AND RECOMMENDED PROGRAMS

The final requirement of Phase II of this project, as defined in the contract, consists of the following:

"Upon completion of the field work, a Statement of Work for a cost-effective research project or projects shall be prepared which is required to eliminate the technologic deficiencies which still exist with regard to satisfying the requirements of the Federal Coal Mine Health and Safety Act in consideration of the integrated evaluation of all known research projects addressed to the particular research area."

In order to consolidate these two objectives, each deficiency has been combined with the subsequent recommended program, so as to cover each subject area with a minimum of duplication. The areas of research have been divided into (1) respirable dust sampling instruments and (2) respirable and float dust control research.

A. Respirable Dust Sampling Instruments

1. Approved Personal Samplers

a. Program 1: Field testing of gravimetric samplers by coal industry investigators and others who used the paired instrument technique has demonstrated most erratic performance by both the MRE gravimetric sampler and the AEC cyclone personal sampler. These studies cast serious doubt on whether or not measurements derived from personal samplers can be accurately converted to MRE equivalent values. It is recommended that a comprehensive two-phase program be undertaken. Phase I would consist of tests in both simulated and actual mine atmospheres to determine the reasons for the erratic performance of the instruments during in-mine testing. The effect of such factors as pump flow rate, dust cloud concentration, size consist of respirable dust, inlet orientation, inlet size, and the reliability of both the electrical and mechanical portions of the sampler, as well as other variables, should be investigated. The estimated cost to undertake Phase I of the program is \$200,000.

Phase II of the program would consist of research work aimed at eliminating the factors causing erratic performance while basically maintaining the general configurations of the present unit. This phase of the program would cost approximately \$100,000.

The total cost of this two-phase program would be \$300,000.

2. Fixed Position Sampler

a. Program 2: The second deficiency in the area of respirable dust sampling is the complete lack of effort to determine whether or not a fixed position sampler similar to the "British Concept" would work in American mines. The program should be designed to correlate the personal respirable dust samplers to the respirable dust level in the return air or

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at an appropriate fixed position near the high-risk operator. The data should be handled statistically in the same manner utilized in determining correlation factors between the personal sampler and the MRE unit.

A program designed to cover the range of American seam characteristics and mining techniques would have an estimated cost, at a minimum of \$150,000.

B. Respirable and Float Dust Control Research

1. Projects to Minimize Dust Production

a. Program 3: The British have undertaken a considerable amount of work on both bit design and machine design. The basic objective of these experiments was to provide data that would enable the equipment manufacturers to design more efficient cutting machines and to show how existing machines should be used to obtain maximum efficiency. Tests were conducted over a range of conditions from initial experiments with single bits to full-scale units utilizing the new concepts derived from the test programs. The following variables were studied:

- (1) Types of coal
- (2) Angle of cleat
- (3) Design of bit
 - (a) rake angles
 - (b) clearance angles
 - (c) size of bit
 - (d) shape of bit
- (4) The degree of blunting
- (5) Depth of cut (bit penetration)
- (6) Speed of cutting
- (7) Effect of relief afforded by bits cutting ahead and parallel to the bit under investigation

It is felt that this area of research is extremely important and that the Bureau's programs in-house dealing with single bit performance and with multiple bits (microminer) are excellent starting points. The on-going program for the Ingersoll-Rand continuous miner should provide the necessary answer for American machine design. We are not indicating a recommended budget for this program since the necessary investigations are being pursued; however, the importance of this program should not be underestimated and the results will apply across the board to all machines.

Therefore, these programs should be continuously funded until all the variables have been investigated and the positive results of research are applied to American machine design.

2. Projects to Minimize Dust Dispersion

a. Program 4: The use of water impinging on the cutting bit offers the greatest potential in eliminating the dispersion of dust after it has been created. One program in this area is presently being funded

by the Bureau of Mines. This work is being conducted by BCR in cooperation with Lee-Norse Company and U.S. Steel Corporation. The progress on this program has been slowed by the problem of inadequate seals in the head of the machine. Visual observation of the dust control (float dust) for the brief periods of time when all of the seals were functioning as designed indicated excellent suppression utilizing this concept.

Because of the erratic seal performance, definitive numbers on respirable dust control have not been obtainable. It has been reported that both a Joy fixed-drum continuous miner and a Jeffrey Heliminer have been operating without seal problems. This is possible, since each machine presents its own peculiar problems of seal design. Both these machines, each with its own variation of the water-flushing concept, should be tested at this time in coal seams with different characteristics.

The water-flushed bit concept should also be tested on the low-coal, twin-auger miner. Although popular in low-seam mining, it is a major dust source.

Both major types of longwall machines, the shearer and plow, should be tested with water-flushing of the bits or of the plow blade.

Additional research and development should be started immediately on the problem of the seals. The present on-going program has been slowed drastically because of the water seal problem. Even though a seal developed in the next step of this program may be acceptable for accomplishing the objectives of the research program, it may not be adequate for commercial use.

Estimated budgets are as follows*:

Sufficient conclusion of the water-flushed bit concept to the Lee-Norse "Hard Head," in order to obtain comparative dust data between water flushing and conventional sprays.....	\$100,000
Test program to evaluate a successfully operating Joy fixed-drum continuous miner.....	\$ 65,000
Test program to evaluate a successfully operating Jeffrey Heliminer.....	\$100,000
Test program to evaluate the water-flushing concept on a twin-auger low-coal miner.....	\$200,000
Test program to evaluate the water-flushing concept on a long-wall shearer.....	\$150,000
Test program to evaluate the water-flushing concept on a long-wall plow.....	\$ 75,000
Seal development program for fixed-drum continuous miners.....	\$ 45,000

* The above costs do not provide for any major machine purchases.

b. Program 5: Water infusion provides a potential for minimizing dust dispersion in certain seams. The Bureau of Mines, on several projects included in this report, and individual coal companies have undertaken test programs on water infusion. Some of the industry's efforts are included in this report, while others, such as that undertaken by the Carbon Fuel Company, which could not be interviewed within the time available, have not been included. It is, therefore, recommended that an industry survey be made of all the research work that has been completed in this general area, including an inventory of successful equipment and techniques utilized.

The estimated cost of this industry-wide survey is \$40,000.

While sprays could conceivably be included under the category of projects to minimize dust dispersion, they are included in the next section.

3. Projects to Optimize Systems to Control Airborne Dust

a. Program 6: A great deal of work has been undertaken by individual coal companies on applying sprays to control dust produced by a wide variety of machines. Successful designs have been reported on all mining units normally used in the conventional mechanized mining plan. Other applications have been made on continuous miners and longwall machines. An industry-wide survey should be implemented to consolidate this information. Each system would be documented by assemblies, drawings, photographs, and the available respirable dust data.

The cost of the survey is estimated to be \$40,000.

b. Program 7: One of the most important methods of controlling airborne dust is the use of ventilating systems. An initial field survey should be made to collect all of the available data from studies made on the many variations obtainable in mine ventilation. Following the survey, full-scale laboratory studies should be initiated to determine the effects of the numerous variables, such as size and shape of a machine in a given place, the location of the brattice cloth and tubing, the effect of velocity and quantity on methane diffusion, and dust removal. The full-scale laboratory studies should be undertaken on both the curtain and tubing blowing system, the curtain and tubing exhaust system, and the push-pull system. The use of diffusers with the previous three systems and the use of a machine-mounted scrubber operating at various throughputs with compatible arrangements from these three systems should also be investigated. These studies should also take into account the differences between high and low coal and between wide and narrow rooms. The possible development of self-advancing ventilating systems to allow easier compliance with the ventilation requirement of P.L. 91-173 should be taken into account in these programs. Following the full-scale laboratory studies, in-depth mine studies should be undertaken.

It is estimated that the ventilation survey would cost \$30,000.

The cost of the full-scale laboratory studies, excluding equipment and test facilities, is estimated at \$70,000.

The cost of the in-depth underground studies is estimated at \$150,000.

c. Program 8: The use of machine-mounted scrubbers as a method of controlling airborne dust has been popular with the coal producers. Table 8 lists 26 operator-sponsored programs. A survey of all the on-going work should be made to consolidate the accomplishments and deficiencies remaining as a result of these operator-controlled test programs. Following this survey, full-scale major studies should be initiated to obtain information on the fate of liberated methane and float dust when using these auxiliary ventilating systems (scrubbers).

Following successful conclusion of these full-scale laboratory tests, an in-depth mine study should be undertaken, investigating the system in combination with compatible ventilation systems as discussed under the Item 3b, Program 7.

The estimated survey cost is \$15,000.

The cost of full-scale laboratory study, with no consideration being given to the cost of equipment or facilities, is estimated at \$40,000.

The cost of the underground studies is estimated at \$100,000.

d. Program 9: A large amount of research has been undertaken with funding both by government agencies and industry to investigate the use of foam as a method to control airborne dust. It is the conclusion of this report that all of the programs have provided inconclusive results; therefore, an in-depth survey should be conducted to determine the exact state-of-the-art and the promise it holds for contributing to dust control.

The estimated cost of this survey is \$15,000.

4. Projects to Remove Workers from Sources of Respirable Dust

a. Program 10: Most of the present problems of health and safety will be progressively minimized as improvements are made in the design of more automatic mining equipment. The ventilation study recommended previously will provide information necessary in the design of a ventilation system for high production more automatic mining. Other topics need to be continuously and energetically studied, including remote control of mining machines, self-advancing ventilation and coal conveyors, remote control of roof bolting machines, and other innovative developments.

It is therefore proposed that a survey be made of Bureau personnel, equipment manufacturers, and coal operators to determine, to the extent that revelations can be made, their views and plans for the development of more automatic and remote controlled systems in the fields of continuous mining, shortwall mining, and longwall mining using either mechanical or hydraulic fragmentation.

After the completion of this survey, the views and plans expressed above should be consolidated into a consensus report. Progress in the development of such items of research and development as self-advancing ventilation, self-advancing conveyors, remote control of machines, remote or automatic

roof bolting, self-advancing roof supports, and hydraulic mining, should be followed; and the report should be periodically updated to reflect new technical developments.

Such a report should be a valuable guide to the more effective funding of research in these important areas of mining, minimize the duplication of effort, and be a useful guide for designing cooperative research programs.

It is recommended that the principal emphasis be placed on developments that, after successful trial application, can be incorporated into existing mining systems rather than on developments that would require radical departures from present mining practice.

VII. INVENTIONS

There are no patentable results or inventions from the work performed under this contract.

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APPENDIX A

Research Project Briefs

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RESEARCH PROJECT BRIEF 5-1
In-house Research by Bureau

1. Organization Performing Research: Pittsburgh Mining and Safety Research Center.
2. Descriptive Project Title: Dust Collector Technology
3. Objective of Project: The objective of the project was to establish a facility for testing dust collectors and to develop improved dust collectors.
4. Summary of Project Progress to Date: An above ground facility has been built to allow the testing of full-scale dust collectors suitable for in-mine application. This facility will be used first to test commercially available scrubbers and then to test scrubber developments. Included in the scrubber developments is a venturi scrubber of U.S. Bureau of Mines design. Test data indicate that the disintegrator type of scrubber alone can readily approach 2.0 mg/m^3 venturi and other type scrubbers have yet to be tested. The data developed to date indicate that scrubbers, in themselves,* are capable of producing exhaust streams with respirable dust concentrations approaching 2.0 mg/m^3 .
5. Remaining Technological Deficiencies: Some installations of scrubbers can significantly modify existing ventilation patterns and thereby introduce a possible explosion hazard. It is felt by many operators that the scrubbing units and the appropriate ducting systems can achieve the following improvements (1) improved face visibility, (2) reduced respirable dust concentrations at the operators station, and (3) cleaner air returns.
6. Schedule and Project Funding: It is expected that this project will be active for several years. This project was funded by the U.S. Bureau of Mines for \$40,000 in 1972.

* Our test data indicates that the disintegrator type of scrubber alone can readily approach 2.0 mg/m^3 and we have yet to test the venturi and other scrubber types.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 23, 1973
Reviewed and revised by Mr. E. Divers, March 16, 1973

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RESEARCH PROJECT BRIEF 5-2
In-house Research by Bureau

1. Organization Performing Research: Pittsburgh Technical Support Center.
2. Descriptive Project Title: Laboratory and Field Evaluation of Integral Machine-Mounted Dust Collectors
3. Objective of Project: To quantitate the effectiveness of existing machine-mounted dust collecting systems for controlling float and respirable coal mine dusts and to evaluate their overall effect on face ventilation and increased noise hazard.
4. Summary of Project Progress to Date: Two underground evaluations have been conducted on a collector designed for integral use with the Jeffrey 120-H Heliminer. One study covered employment in a blowing face-ventilation system, the other in an exhausting face-ventilation system. In addition, in-depth laboratory studies have been completed on units from three manufacturers.
5. Remaining Technological Deficiencies: There are many technological deficiencies associated with the application of scrubbers. Among these are (a) obtaining the optimum potential efficiency underground, (b) controlling increased noise levels, and (c) effects on face-ventilation patterns.
6. Schedule and Project Funding: No details available.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 25, 1973
Reviewed and revised by Mr. T. Tomb, February 12, 1973

RESEARCH PROJECT BRIEF 5-3
In-house Research by Bureau

1. Organization Performing Research: Pittsburgh Technical Support Center.
2. Descriptive Project Title: Methane Dilution Characteristics of Face Ventilation Systems Incorporating Integral Machine Mounted Dust Collectors
3. Objective of Project: To determine the methane dilution ability of various face ventilation techniques employing integral machine mounted dust collectors.
4. Summary of Project Progress to Date: A full scale mock-up of a mine entry has been constructed and is being equipped with variable methane release sources. Recording instrumentation is being installed. A scale model of a continuous mining machine with functional cutter head has been provided. Methane concentrations throughout the face area will be continuously monitored under simulated operating conditions with various ventilating techniques.
5. Remaining Technological Deficiencies: The primary problem is to develop safe and efficient face ventilation systems incorporating integral machine mounted dust collectors which are capable of high dust capture without adverse noise generation.
6. Schedule and Project Funding: No details available.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 25, 1973
Reviewed and revised by Mr. R. Dalzell, February 27, 1973

RESEARCH PROJECT BRIEF 5-4
In-house Research by Bureau

1. Organization Performing Research: Pittsburgh Mining and Safety Research Center.
2. Descriptive Project Title: Control of Respirable Dust by Water Infusion
3. Objective of Project: The evaluation in the field of techniques and equipment developed by the U.S. Bureau of Mines "in-house" and by contract.
4. Summary of Project Progress to Date: Field tests have been conducted in three mines to date. The tests have been slow, expensive, and time-consuming. Encouraging reductions in both dust production and the release of methane from the face have been observed. The findings to date are being summarized for a Report of Investigation.
5. Remaining Technological Deficiencies: The integration of water infusion into the high production U.S. coal mining operations will require considerable engineering developments, mainly on a mine by mine basis. Successful water infusion has the promise of reducing dust and methane emissions from the face.
6. Schedule and Project Funding: Further field work is planned for 1973. This project was funded by the U.S. Bureau of Mines for \$55,000 in 1972.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 19, 1973
Reviewed by Dr. M. Zabetakis, January 23, 1973

RESEARCH PROJECT BRIEF 5-5
In-house Research by Bureau

1. Organization Performing Research: Pittsburgh Mining and Safety Research Center.
2. Descriptive Project Title: Control of Respirable Dust by Stemming
3. Objective of Project: Compare dry and hydraulic water stemming for suppression of dust from blasting.
4. Summary of Project Progress to Date: Concentrations of respirable dust were determined after blasting, using clay and hydraulic stemming. The tests confirmed the European experience that less respirable dust was produced with hydraulic stemming. Examination of the dust produced in these tests indicates that the clay used as stemming material was the principal source of the dust.
5. Remaining Technological Deficiencies: None
6. Schedule and Project Funding: This project is essentially complete. This project was funded by the U.S. Bureau of Mines for \$10,000 in 1972.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 23, 1973
Reviewed by Dr. W. Courtney, March 16, 1973

RESEARCH PROJECT BRIEF 5-6
In-house Research by Bureau

1. Organization Performing Research: Pittsburgh Mining and Safety Research Center.
2. Descriptive Project Title: Nature and Behavior of Mine Dust
3. Objective of Project: The objective of the project was to conduct 1/10 scale model experiments of the mine face. Air was used to predict the behavior of fine particulates released at the face. This project also included some laboratory work on the concept of autogenous electrostatic precipitation.
4. Summary of Project Progress to Date: The study was made in conjunction with the Clinchfield Coal Company contract "Environmental Dust Survey." The model experiments indicated that the following factor influenced the transport of respirable dust to the critical working stations:
 - Location of brattice - This was found to be the most critical item-- at 10 ft ventilation minimized dust; at 20 ft severe dust problems appeared likely at work areas.
 - Ventilation - Increasing ventilation air rate improved dust suppression until a certain critical rate was reached.
 - Air through center of machine - Bringing a split of ventilating air back through the center of the machine improved dust suppression.The findings from the model test were conclusive and are being validated by the full-scale tests by Clinchfield Coal.
 - The charging studies indicated that 40 to 50 percent of the respirable dust could be captured as air flowed through plastic tubes. The Lehigh University study "Spontaneous Electrostatic Precipitation of Dust" was initiated as part of this program. Plans are being made to study respirable dust capture when air flows through the plastic tubes at a flow rate equivalent to a 5,000 cfm prototype collector.
5. Remaining Technological Deficiencies: Success of the model program will depend upon results obtained by the Clinchfield coal study. The autogenous electrostatic dust collector may have merit if a simple unloading system can be devised.
6. Schedule and Project Funding: Further model studies and studies of autogenous electrostatic collection are scheduled for 1973. This project was funded by the U.S. Bureau of Mines for \$50,000 in 1972.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 23, 1973
Reviewed and revised by Dr. W. Courtney, March 16, 1973

RESEARCH PROJECT BRIEF 5-7
In-house Research by Bureau

1. Organization Performing Research: Twin Cities Mining Research Center.
2. Descriptive Project Title: Reduction of Airborne Coal Dust by the Optimization of Continuous Mining Machine Parameters
3. Objective of Project: To devise efficient fragmentation that will minimize respirable and float dust production during coal mining. This will be achieved through the study of the fragmentation characteristics of coal and the particle size distribution of the generated dust as influenced by parameters of a laboratory linear coal cutter and a small continuous miner (microminer).
4. Summary of Project Progress to Date: Linear cutter tests have been completed with Illinois, Iowa and Pittsburgh seam coal. Tests have been conducted with six different bit types at varying depth of cut, and spacings at the same bit speed. Differences in production of respirable dust were noted with changes in bit type, angle and depth of cut. Dust emissions were similar with Pittsburgh and Illinois No. 6 seam coals and higher with Iowa coal.
The microminer was tested at the Bruceton experimental mine and shipped to Twin Cities. The following read-out was being calibrated-- drum speed, sump and shear rates, sump and shear forces, cutting torque.
Techniques have been developed for preparing large test samples of coal and homogeneous coal-like materials.
As part of this program coal dust aerosol monitoring services have been supplied as necessary to all "in-house" dust research at Twin Cities and on contracts such as IITRI.
5. Remaining Technological Deficiencies: Valid testing with sufficient replication of data is time consuming.
The parameters evaluated from these small scale tests are expected to make valuable contributions to the design of full-scale experiments such as with the Ingersoll Rand miner or other tests by coal producers. It is felt that these small scale tests should only be regarded as indicative until substantiated by full-scale tests.
6. Schedule and Project Funding: This project is a continuing program. This project is funded by the U.S. Bureau of Mines for \$135,000 in fiscal 1973.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 12, 1973
Reviewed and revised by Mr. Kelly Strebbig, February 26, 1973

RESEARCH PROJECT BRIEF 5-8
In-house Research by Bureau

1. Organization Performing Research: TCMRC.
2. Descriptive Project Title: Coal Dust Formation by Abrasion
3. Objective of Project: To determine the amount of airborne dust generated from coal/steel abrasion. If abrasion is a serious source of dust, the results of the research will be used to aid in the design of bits that minimizes abrasion.
4. Summary of Project Progress to Date: A chamber was built to collect the dust generated from single or multiple traverses of a steel probe against a static coal sample. Tests have been completed with Illinois No. 6 seam coal and are nearly completed with Pittsburgh coal. This program is nearing completion.
5. Remaining Technological Deficiencies: The test results, and impression gained in the laboratory indicate fairly conclusively that steel to coal abrasion is not a major source of dust generation.
6. Schedule and Project Funding: This project will be completed in fiscal 1973. This project is funded by the U.S. Bureau of Mines for \$25,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 12, 1973
Reviewed and revised by Mr. B. Snowden, February 26, 1973

RESEARCH PROJECT BRIEF 5-9
In-house Research by Bureau

1. Organization Performing Research: TCMRC.
2. Descriptive Project Title: Influence of Hydraulic Fragmentation of Coal on Dust and Noise Generation
3. Objective of Project: The specific goals are to determine the respirable dust generated and noise levels associated with the hydraulic fragmentation of coal. Measurements will be made in a coal mine and in the laboratory to determine the amount of respirable dust and the noise levels associated with jet cutting of coal.
4. Summary of Project Progress to Date: Field tests were conducted with Conoco at the Humphrey No. 7 Mine (Mt. Morris, Pa.). Consolidation coal personnel operated their own cutting experiment. Bureau of Mines personnel observed the tests and made measurements of noise and respirable dust levels under a proprietary cooperative agreement.
5. Remaining Technological Deficiencies: Hydraulic mining may have excellent prospects for future mining systems but more immediate solutions are required to reduce the dust from current mining systems.
6. Schedule and Project Funding: The project is being completed in fiscal 1973. The Bureau of Mines portion of the project is funded by the Bureau of Mines for \$42,000 in fiscal 1973.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 12, 1973
Reviewed by Mr. J. Frank, February 26, 1973

RESEARCH PROJECT BRIEF 5-10
In-house Research by Bureau

1. Organization Performing Research: TCMRC.
2. Descriptive Project Title: Research on Physical Properties of Coal and Coal Strata Rocks
3. Objective of Project: Determine the properties of coal and associated rock strata which govern the generation of dust during mining operations. Evaluate differences in major coals based on intrinsic dust generation characteristics. Support the activities of other Coal Mine Health and Safety research projects at this or other Bureau Centers through mechanical/physical property studies and specimen preparation services.
4. Summary of Project Progress to Date: Coal Specimens are being prepared, placed in plastic bags and crushed in the compression testing apparatus. The size distribution of the crushed product and the data obtained during the crushing enable properties of the coals including their inherent dustiness to be compared.
5. Remaining Technological Deficiencies: It is hard to prepare a specimen of coal without losing some of the softer and presumably dustier entities during collection and preparation. It is not realistic to process sufficient bulk specimens to give a statistically reliable sample of a seam. It is hard to maintain the seam moisture during storage. Determination of the size distribution of the ultra fines is expensive.
6. Schedule and Project Funding: This project is part of a continuing program directed toward reducing coal dust by improving mining machine parameters. The project is funded by the U.S. Bureau of Mines for \$31,000 in fiscal 1973.

Project Brief prepared by Bituminous Coal Research, Inc.

Submitted for review February 12, 1973

Reviewed and revised by Mr. P. Chamberlain, February 26, 1973

RESEARCH PROJECT BRIEF 5-11
In-house Research by Bureau

1. Organization Performing Research: TCMRC.
2. Descriptive Project Title: Fractography and Fracture Surface Mapping in Coal and Associated Rocks.
3. Objective of Project: To use micro and macro topographic information to compare different kinds of fractures with different modes of applying energy to produce the fracture and to determine the fracture process that requires the least amount of energy.
4. Summary of Project Progress to Date: The microtopography of grooves cut in coal blocks was studied with a profilometer and scanning electron microscope. No residual, compacted dust from the cutting process was found in microstriations along groove floors. Rather, groove floors contained smear structures and possible chattermarks, in addition to the striations.

Bit geometry was found to influence groove development: narrow, steep walled grooves are associated with rectangular bits and wide grooves with flared out walls with conical bits. In both cases, natural pre-existing fractures were found to influence the size and shape of chips broken out along the grooves.

Coal blocks were found to differ in their "dust index" despite similar cutting conditions. The index is a number representing a tendency to produce fines during cutting.

The spacing of microcracks in fusain was found to be 60-65 μm and a function of cellular structure in fossil plant material.
5. Remaining Technological Deficiencies: It is difficult to associate specific respirable size particles of coal with parent material, and therefore difficult to determine which varieties of coal have the greater tendency to produce respirable fines. Identify microcrack spacing in vitrain. Determine amounts of dust produced by crushing and fracturing during bit impingement on coal.
6. Schedule and Project Funding: This project is a continuing program. The project is funded by the U.S. Bureau of Mines for \$36,000 in fiscal 1973.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 12, 1973
Reviewed and revised by Mr. R. Willard, February 26, 1973

RESEARCH PROJECT BRIEF 5-12
In-house Research by Bureau

1. Organization Performing Research: Pittsburgh Mining and Safety Research Center.
2. Descriptive Project Title: Dust Control At and Outby the Face
3. Objective of Project: The purpose of the project is to develop a mathematical model of respirable dust control by impact wetting and by capture by water droplets.
4. Summary of Project Progress to Date: A procedure has been developed to predict the effectiveness of a given spray for dust suppression and thereby to optimize the dust collection at a given flow rate. Laboratory work is proceeding on the impaction of droplets on coal surfaces. Measurements have been made of the respirable dust adhering to larger coal particles and it has been determined that most of the respirable dust produced in mining does not become airborne. Progress in this project is encouraging and it is expected that the finding will soon be complete enough to permit them to be reported in an R.I.
5. Remaining Technological Deficiencies: It remains to be shown whether this study will allow a significant reduction in field work presently required to optimize a spray system.
6. Schedule and Project Funding: It is expected that this program will be continued. The project was funded by the U.S. Bureau of Mines for \$110,000 in 1972.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 26, 1973
Reviewed and revised by Dr. W. Courtney, March 16, 1973

RESEARCH PROJECT BRIEF 5-13
In-house Research by Bureau

1. Organization Performing Research: TCMRC.
2. Descriptive Project Title: Prediction of Coal Dust Generation by Mathematical Model
3. Objective of Project: To develop mathematical expressions for the primary distribution of the products of coal breakage based on data obtained from laboratory tests.
4. Summary of Project Progress to Date: Breakage tests were conducted on coal samples using classic drop-shatter techniques. Tests are now being conducted using the single impact breakage by a pendulum mounted drop hammer. During these tests attempts were made to evaluate the energy converted to size reduction. The size distribution of the broken coal is obtained including the size of the ultra fines. Attempts are being made to fit the data obtained to mathematical models that relate energy applied in breakage to the size distribution of the broken coal.
5. Remaining Technological Deficiencies: Despite the availability of computers for data processing, analysis of the data collected to date has been found to be unexpectedly difficult.
6. Schedule and Project Funding: This project is a continuing program. This project is funded by the U.S. Bureau of Mines for \$40,000 in fiscal 1973.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 12, 1973
Reviewed by Mr. D. Kurth, February 26, 1973

RESEARCH PROJECT BRIEF 5-14
In-house Research by Bureau

1. Organization Performing Research: PTS.
2. Descriptive Project Title: Determining New Relationship Between MRE and Modified Personal Sampling Equipment
3. Objective of Project: Comparison of Respirable Dust Concentrations Measured with MRE and Modified Personal Gravimetric Sampling Equipment.
4. Summary of Project Progress to Date: Instrument packages that house 1 MRE, 1 Unico, and 1 MSA samplers were distributed to 9 health and safety districts. These instrument packages were set to sample in a static location 3 ft from the operator of a continuous mining machine. The data on 1,100 paired comparisons were collected and analyzed and a new relationship between personal sampler and MRE has been recommended.
5. Remaining Technological Deficiencies: The conclusion developed by the PTS still has to be reviewed.
6. Schedule and Project Funding: The project was started December 1972, field work was completed March 1972. The cost of the project was shared with the PTS and the health and safety districts. The estimated cost is not available.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for Review January 24, 1973
Reviewed and revised by Mr. T. Tomb, February 5, 1973

RESEARCH PROJECT BRIEF 5-15
In-house Research by Bureau

1. Organization Performing Research: Pittsburgh Mining and Safety Research Center.
2. Descriptive Project Title: Characterization of Mine Dust Particle
3. Objective of Project: The purpose of the project is to investigate the capabilities of the scanning electron microscope to evaluate specific properties of respirable dust.
4. Summary of Project Progress to Date: A scanning electron microscope was purchased set up and operated in a similar manner to the Penn State unit. This machine is being used to support other "in-house" dust control projects and to try to determine if there are characteristics in the respirable dust that typify certain coal seams, methods of mining, etc.
5. Remaining Technological Deficiencies: This project is essentially supportive in nature and is not expected to lead directly to improvements in dust measurement or control.
6. Schedule and Project Funding: It is expected that this project will be maintained for the duration of any PM & SRC dust control effort. The project was funded by the U.S. Bureau of Mines for \$80,000 in 1972.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 26, 1973
Reviewed by Dr. W. Courtney, March 16, 1973

RESEARCH PROJECT BRIEF 5-16
In-house Research by Bureau

1. Organization Performing Research: Pittsburgh Mining and Safety Research Center.
2. Descriptive Project Title: Aerodynamic Behavior of Mine Particles
3. Objective of Project: The objective of the project is to study the behavior of irregular fine dust particles at entries, returns, and especially in sampling devices.
4. Summary of Project Progress to Date: This project title covers a variety of smaller tasks, each with individual schedules. (1) Determination of extent of agglomeration of coal mine dust--samples penetrating a 10 mm cyclone were compared to samples taken with impinger and Anderson sampler. It has been determined that electrostatic effects at low humidity and the re-entrainment of agglomerated respirable size fines do not materially affect the performance of the 10 mm cyclone. It has been determined that 50 percent of the 1 to 2 micron particles associated with breathable fines comprise part of the coarse non-respirable sizes. (2) Study of Rapid Dust Analyzers - The SRI and GCA rapid dust samplers have been evaluated in the laboratory. Both instruments appear to have merits for a mine diagnosis but do not appear suitable for short term enforcement measurements. (3) Deposits in Airways - The deposits on the floor, walls, roofs of airways have been evaluated. The thickness gradients noted indicate that the mechanism of deposition is not properly understood. (4) Sampling Tubes - The theoretical and actual sampling efficiencies were found to be in reasonable agreement. Aerodynamic and Coulter counter sizes were found to be comparable.
5. Remaining Technological Deficiencies: The factor contributing to the uncertain behavior of available respirable dust samplers has not been evaluated.
6. Schedule and Project Funding: It is expected that this broad based program will be continued in 1973. This project was funded by the U.S. Bureau of Mines in 1972, with an initial \$28,000 budget which was expanded to \$48,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 26, 1973
Reviewed by Dr. W. Courtney, March 16, 1973

RESEARCH PROJECT BRIEF 5-17
In-house Research by Bureau

1. Organization Performing Research: Pittsburgh Mining and Safety Research Center.
2. Descriptive Project Title: Determination of Free Silica
3. Objective of Project: To improve laboratory techniques for analyzing the quartz content of dust samples.
4. Summary of Project Progress to Date: New techniques are being developed to redeposit the material from a sampler filter onto another filter of more suitable material. It is hoped that it will be possible to analyze dust samples in situ by processing the filters used in samplers.
5. Remaining Technological Deficiencies: It would be very desirable to have a rapid quantitative free silica analysis that involved simply reading the filter from a sampler.
6. Schedule and Project Funding: This program will continue in 1973. The project was funded by the U.S. Bureau of Mines for \$55,000 in 1972.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 26, 1973
Reviewed and revised by Dr. W. Courtney, March 16, 1973

RESEARCH PROJECT BRIEF 6-1
Grant or Contract Research for Bureau

1. Organization Performing Research: Apt, Bramer, Conrad and Associates.
2. Descriptive Project Title: Engineering Methods Used to Control Respirable Dust in Underground Mines
3. Objective of Project: The purpose of the project was to investigate the developing art of dust control and to publish the findings in the form of a manual for coal operators.
4. Summary of Project Progress to Date: The project has been completed and the manual is available as an open file report.
5. Remaining Technological Deficiencies: Since the art of dust control is rapidly changing, some means are required to update the manual.
6. Schedule and Project Funding: The project was started June 1971 and the manual was delivered August 1972. The project was funded by the U.S. Bureau of Mines for \$50,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 18, 1973
Reviewed by Dr. W. Courtney February 13, 1973

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RESEARCH PROJECT BRIEF 6-2
Grant or Contract Research for Bureau

1. Organization Performing Research: Ingersoll Rand Research.
2. Descriptive Project Title: Design and Construction of Continuous Mining Machine
3. Objective of Project: Develop a full-scale, instrumented, continuous mining machine and perform a series of underground experiments with this machine. The objective is to determine which machine parameter, or combination of parameters, gives optimum performance from the standpoint of generation of respirable dust.
4. Summary of Project Progress to Date: The miner is scheduled for shop tests in March, 1973, with underground testing to start in April, 1973.
5. Remaining Technological Difficulties: The machine will have to be taken underground and tested. The principal concern is obtaining meaningful data with the varying conditions that also modify the generation of dust.
6. Schedule and Project Funding: Completion of this contract is scheduled for July 1973. Some extension is anticipated with the same budget allocation. This project is funded by the U.S. Bureau of Mines for \$778,495 in fiscal 1973. Eastern Associated Fuels will be contributing supplies, power, ventilation, haulage, roof bolting and alternative employment for operators when the machine is not to be operated.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 12, 1973
Reviewed and revised by R. Schmidt, February 26, 1973

RESEARCH PROJECT BRIEF 6-3
Grant or Contract Research for Bureau

1. Organization Performing Research: Clinchfield Coal Company.
2. Descriptive Project Title: Environmental Dust Survey
3. Objective of Project: The objective of the project was to assist the Clinchfield Coal Company in development of a dust collecting system for a low coal auger head mining machine.
4. Summary of Project Progress to Date: It was found that the dust concentrations in two critical work areas could be reduced by drawing some of the ventilation air through the machine. Plans have been made to install a scrubber to dedust this air before it is exhausted at the rear of the machine. This approach to dust suppression appears promising for this type of mining machine.
5. Remaining Technological Deficiencies: The scrubber assembly has yet to be installed and tested.
6. Schedule and Project Funding: The project was started March 1972 with completion scheduled for March 1973. The project is, however, behind schedule. The project is funded on a shared cost agreement between the U.S. Bureau of Mines and the Clinchfield Coal Company. The U.S. Bureau of Mines share (reportedly 45 percent of total) is \$115,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 18, 1973
Reviewed by Dr. W. Courtney, February 13, 1973

RESEARCH PROJECT BRIEF 6-4
Grant or Contract Research for Bureau

1. Organization Performing Research: Monsanto Research Corporation.
2. Descriptive Project Title: Foam Suppression of Respirable Coal Dust
3. Objective of Project: The object of the project is to develop and test a full-scale installation of a foam system on a continuous miner.
4. Summary of Project Progress to Date: Exploratory tests were conducted with foam spray nozzles installed in the field. A foam spray system was then designed and has been installed on a Joy 12 CM miner that had also been previously fitted with an experimental scrubber. The initial tests with this modified miner were scheduled for January 1973 at the Mathies mine of Consolidation Coal Company.
5. Remaining Technological Deficiencies: The first real test of this foam system has yet to be carried out. For success (at an estimated cost of 10-15¢/ton) with such a system, it will be necessary to demonstrate sustained trouble-free operation after optimization.
6. Schedule and Project Funding: The project was started March 1971 and completion is scheduled for June 1973. The project is funded by the U.S. Bureau of Mines for \$329,000. It is not known if the Joy Manufacturing Company or the Consolidation Coal Company is contributing to this program.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 18, 1973
Reviewed and revised by Dr. W. Courtney, February 13, 1973

RESEARCH PROJECT BRIEF 6-5
Grant or Contract Research for Bureau

1. Organization Performing Research: DeTer Company.
2. Descriptive Project Title: Dust Suppression in Coal Mines
3. Objective of Project: Field evaluation of the use of foam for dust suppression and fire extinguishment at belt transfer points.
4. Summary of Project Progress to Date: Repeated field test at a transfer point showed significantly lower respirable dust levels when foam was used instead of water sprays. The fire extinguishing properties of this foam were found to be adequate.
5. Remaining Technological Deficiencies: The cost of a high density foam system appears to be inherently too high for a coal mining application.
6. Schedule and Project Funding: The project was started February 1971 and was completed July 1972. The project was funded by the U.S. Bureau of Mines for \$122,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 18, 1973
Reviewed by Dr. W. Courtney, February 13, 1973

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RESEARCH PROJECT BRIEF 6-6
Grant or Contract Research for Bureau

86.

RESEARCH PROJECT BRIEF 6-8
Grant or Contract Research for Bureau

1. Organization Performing Research: Envirotech Corporation.
2. Descriptive Project Title: Coal Mine Vacuum Sweeper
3. Objective of Project: The objective of the project is to demonstrate a feasible system to dedust the floor, ribs, etc. of the entries, returns, and working faces in underground mines.
4. Summary of Project Progress to Date: A feasibility study is being conducted to determine how such a vacuum system would be built. It has been decided that a wet collection system would be more safe and practical than a dry bag collector. At present, various components are being tested to determine the design of a prototype system.
5. Remaining Technological Deficiencies: Vacuum sweeping appears to be a potential improvement over rock dusting. There are, however, many technological problems involved, including water supply, slurry removal, accessibility, etc.
6. Schedule and Project Funding: The program was started in April 1972 and completion is scheduled for December 1973. The project is funded by the U.S. Bureau of Mines for \$484,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 18, 1973
Reviewed and revised by Dr. W. Courtney, February 13, 1973

RESEARCH PROJECT BRIEF 6-9
Grant or Contract Research for Bureau

1. Organization Performing Research: Battelle Memorial Institute.
2. Descriptive Project Title: Microminer Research Dust Generator
3. Objective of Project: To develop and manufacture a single wheel permissible mining machine.
4. Summary of Project Progress to Date: The mining machine has been built and shipped. It was demonstrated at the Bureau of Mines, Experimental Mine and functioned properly. The machine has been shipped to the Twin Cities station and is undergoing calibration and preliminary testing.
5. Remaining Technological Deficiencies: The permissibility of the machine has to be confirmed.
6. Schedule and Project Funding: The project was started June 1971; was initially scheduled for completion March 1972; was rescheduled for February 1973. The project was funded by the U.S. Bureau of Mines for \$187,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 18, 1973
Reviewed and revised by Dr. W. Courtney, February 13, 1973

RESEARCH PROJECT BRIEF 6-10
Grant or Contract Research for Bureau

1. Organization Performing Research: Illinois Institute of Technology, Research Institute.
2. Descriptive Project Title: Coal Mining Using High Pressure Water Jets
3. Objective of Project: To determine the feasibility of mining coal by high pressure water jets at a rate competitive with that produced by modern mechanical methods and to evaluate the associated noise and health hazards.
4. Summary of Project Progress to Date: Laboratory tests have been conducted and field tests with pressures in the 50,000 psi range have been completed at Peabody Coal Company's Wilmington mine. Measurements of dust levels have been made and preliminary analysis indicates low levels. Noise control appears to be a matter of proper operation.
5. Remaining Technological Deficiencies: Hydraulic mining may have excellent prospects for future mining system.
6. Schedule and Project Funding: This contract has been extended and is close to its scheduled completion. An extension of the contract is being considered. This project was funded by the U.S. Bureau of Mines for \$192,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 12, 1973
Reviewed and revised by Mr. J. Frank, February 26, 1973

RESEARCH PROJECT BRIEF 6-11
Grant or Contract Research for Bureau

1. Organization Performing Research: Bituminous Coal Research, Inc.
2. Descriptive Project Title: Study of Continuous Mining Machine Bit Technology
3. Objective of Project: To determine the State-of-the-Art in Continuous Mining Machine Bit Technology and potential improvements in bit design to reduce the quantity of dust generated during the fragmentation process.
4. Summary of Project Progress to Date: Visits have been made to interview representatives of mining machine manufacturing companies, manufacturer of bits, and coal producing companies. Information was obtained on a number of aspects of bit utilization. Specifics of 9 sets of unpublished bit related tests were uncovered. In January 1973 the visitations were completed and the data were being compiled and put into a final report.
5. Remaining Technological Deficiencies: It appears that the desired information was obtained by the contractor.
6. Schedule and Project Funding: The project is scheduled for completion in April 1973. The project is funded by the U.S. Bureau of Mines for \$58,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 12, 1973
Reviewed by Mr. K. Strebis, February 26, 1973

RESEARCH PROJECT BRIEF 6-12
Grant or Contract Research for Bureau

1. Organization Performing Research: Lehigh University.
2. Descriptive Project Title: Spontaneous Electrostatic Precipitation of Dust
3. Objective of Project: Laboratory investigation of electrostatic phenomena of polymer surfaces.
4. Summary of Project Progress to Date: Several common polymer surfaces have been investigated to determine how much charge they can hold. Surfaces with added charge enhancers were similarly investigated. Brief studies were conducted on the interaction between polymer surfaces and dust being deposited on that surface.
5. Remaining Technological Deficiencies: The data developed to date indicate little prospect for increasing the efficiency of autogenous electrostatic dust collector by using new polymer surfaces.
6. Schedule and Project Funding: The project was started December 1971 and completion is scheduled for August 1973. The project is funded by the U.S. Bureau of Mines for \$30,000.

Project Brief prepared by Bituminous Coal Research, Inc.

Submitted for review January 18, 1973

Reviewed and revised by Dr. W. Courtney, February 13, 1973

RESEARCH PROJECT BRIEF 6-13
Grant or Contract Research for Bureau

1. Organization Performing Research: Syracuse University Research Institute.
2. Descriptive Project Title: Investigation of Physics of Adhesion of Coal Aerosols
3. Objective of Project: The study of the adhesive forces between respirable dust and coal substrate.
4. Summary of Project Progress to Date: The adhesive forces of respirable dust to coal substrate have been studied in air with up to 50 percent relative humidity. The adhesive forces were found comparable to those in other systems.
5. Remaining Technological Deficiencies: Adhesive forces in air up to 90 percent relative humidity need to be evaluated. It is expected that the objective of the project will be achieved during the balance of the program.
6. Schedule and Project Funding: The project was started June 1972 and completion is scheduled for June 1973. The project is funded by the U.S. Bureau of Mines for \$109,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 18, 1973
Reviewed by Dr. W. Courtney, February 13, 1973

RESEARCH PROJECT BRIEF 6-14
Grant or Contract Research for Bureau

1. Organization Performing Research: Brown University.
2. Descriptive Project Title: Acoustic Separation Process
3. Objective of Project: The purpose of the project was to investigate acoustic scrubbers for dust removal.
4. Summary of Project Progress to Date: Several mechanisms using acoustics were compared with filtration to evaluate the feasibility of acoustic scrubbing. It was determined that acoustic scrubbing might be a feasible method of dust removal but not practical in comparison with available wet scrubbing.
5. Remaining Technological Deficiencies: Acoustic scrubbing is not considered a practical system for further development.
6. Schedule and Project Funding: The project was started June 1971 as a two-year project. The contractor requested termination January 1973. The project is funded by the U.S. Bureau of Mines for a total cost that will be less than the \$83,000 allocated for the two-year program.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 18, 1973
Reviewed by Dr. W. Courtney, February 13, 1973

RESEARCH PROJECT BRIEF 6-15
Grant or Contract Research for Bureau

1. Organization Performing Research: Centre d'Etudes et de Recherches de des Charbonnages de France (CERCHAR).
2. Descriptive Project Title: Develop a Personal Dust Sampler
3. Objective of Project: Adapt high volume mine dust sampler to the requirements of the American coal mining industry as a personal sampler.
4. Summary of Project Progress to Date: The prototype model has been completed. The contractor has been given approval to build a final model which will have to be approved by the Bureau for permissibility. The project is on schedule, the costs are within the budget, delivery is expected in February.
5. Remaining Technological Deficiencies: It will be necessary to test the two final models in the laboratory and underground.
6. Schedule and Project Funding: The project was started February 1972 and completion is scheduled February 1973. The project is funded by the U.S. Bureau of Mines for \$65,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 18, 1973
Reviewed by Dr. W. Courtney, February 13, 1973

RESEARCH PROJECT BRIEF 6-16
Grant or Contract Research for Bureau

1. Organization Performing Research: Stanford Research Institute.
2. Descriptive Project Title: Portable Mine Dust Concentration Instrument
3. Objective of Project: Development of a prototype, portable, light scattering machine, for obtaining rapid measurements of total dust or respirable dust.
4. Summary of Project Progress to Date: The project is technically complete. Two prototype units have been delivered. The units have functioned well in the laboratory with dust loading up to 5.0 mg/m³.
5. Remaining Technological Deficiencies: The unit still needs to be tested underground and to be compared with a personal sampler. The prototypes are considered usable instruments but it is suggested that further optimization would be desirable in a commercial instrument.
6. Schedule and Project Funding: The project was started May 1971 and completed August 1972. The project was funded by the U.S. Bureau of Mines for \$71,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 18, 1973
Reviewed by Dr. W. Courtney, February 13, 1973

RESEARCH PROJECT BRIEF 6-17
Grant or Contract Research for Bureau

1. Organization Performing Research: University of Minnesota.
2. Descriptive Project Title: Research to Develop Instruments and Techniques for Making Dynamic Measurements of Coal Dust During Experimental Cutting Tests
3. Objective of Project: To develop instruments and techniques for making measurements of airborne, respirable coal dust produced in experimental coal cutting tests conducted in the laboratory, field, and underground.
4. Summary of Project Progress to Date: Two systems have been developed - an optical counter with the necessary data acquisition and analysis systems and necessary auxiliaries. This equipment is mounted in a trailer. Another system is a quartz crystal mass monitor which can be used with the necessary auxiliary equipment to measure the respirable fraction that penetrates a personal sampler cyclone.
The contractor is aiding in the setting up and calibration of this equipment and is still making improvements. This equipment has been effectively used for coal and metal and non metal dust research.
5. Remaining Technological Deficiencies: A portable, permissible optical counter still has to be modified to enable dust measurement during coal cutting tests underground.
6. Schedule and Project Funding: It is expected that this contract will be largely complete in 1973. This project is funded by the U.S. Bureau of Mines for \$37,000 in fiscal 1973.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 13, 1973
Reviewed and revised by Mr. H. W. Zeller, February 26, 1973

RESEARCH PROJECT BRIEF 6-18
Grant or Contract Research for Bureau

1. Organization Performing Research: University of Pittsburgh.
2. Descriptive Project Title: Penetration Characteristics of a 10 mm Nylon Cyclone
3. Objective of Project: The purpose of the project is to determine the flow rate at which the penetration curve of the 10 mm cyclone best matches the AEC pulmonary deposition curve. The purpose is to further examine the performance of the cyclone with dust fractions produced from different coals and at different relative humidities.
4. Summary of Project Progress to Date: It has been determined that the best match to the AEC curve is at 2.0 liters/min. No systematic effects of relative humidity or coal-type were noted.
5. Remaining Technological Deficiencies: It is expected that the desired answers will be obtained by August 1973.
6. Schedule and Project Funding: The project was started August 1971 and completion is scheduled for August 1973. The project is funded by the U.S. Bureau of Mines for \$121,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 18, 1973
Reviewed and revised by Dr. W. Courtney, February 13, 1973

RESEARCH PROJECT BRIEF 6-19
Grant or Contract Research for Bureau

1. Organization Performing Research: Lehigh University.
2. Descriptive Project Title: Fluid Dynamics of Small Particle Transport and Deposit
3. Objective of Project: Theoretical and experimental study of particle flow into sampling tube orifices to determine if presently used dust samplers are correctly sampling respirable dust.
4. Summary of Project Progress to Date: Tests with midget impinger have indicated that for still air and if particles weight is ignored, samplers are accurate up to 10 microns.
5. Remaining Technological Deficiencies: Further tests are required to evaluate the effects of air movement and mass of particles.
6. Schedule and Project Funding: The project was started January 1972. Completion was scheduled for January 1973 but an extension has been recommended by the Technical Project Officer. The project is funded by the U.S. Bureau of Mines for \$53,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 18, 1973
Reviewed and revised by Dr. W. Courtney, February 13, 1973

RESEARCH PROJECT BRIEF 6-20
Grant or Contract Research for Bureau

1. Organization Performing Research: Mine Safety Appliances.
2. Descriptive Project Title: Development of a Simple, Rapid Analysis Method for Respirable Dust
3. Objective of Project: The objective of the project is to develop techniques for determining the mineralogical content of mine dust samples.
4. Summary of Project Progress to Date: Infrared techniques appear feasible for measuring the silica and rock contents of sample collected on the filter of a respirable dust sampler. A round-robin test is being conducted to determine reproducibility of the technique. Construction of a prototype infrared analyzer has been started.
5. Remaining Technological Deficiencies: There can be no assurance that a reliable reproducible analyzer will yield meaningful data on the free silica contents of filter samples.
6. Schedule and Project Funding: The project was started March 1972 and completion is scheduled for May 1973. The project is funded by the U.S. Bureau of Mines for \$60,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 18, 1973
Reviewed by Dr. W. Courtney, February 13, 1973

RESEARCH PROJECT BRIEF 6-21
Grant or Contract Research for Bureau

1. Organization Performing Research: Virginia Polytechnic Institute.
2. Descriptive Project Title: Preparation of Pure and Impurity Stabilized Polymorphs of SiO_2
3. Objective of Project: The objective of the project is to prepare silica dust standards for the calibration of infrared analyzer.
4. Summary of Project Progress to Date: The preparation of the desired standards is proceeding satisfactorily.
5. Remaining Technological Deficiencies: It remains to be demonstrated whether the silica standards will compare with coal-based silicas.
6. Schedule and Project Funding: The project was started June 1972 and completion is scheduled for June 1973. The project is funded by the U.S. Bureau of Mines for \$33,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 18, 1973
Reviewed and revised by Dr. W. Courtney, February 13, 1973

RESEARCH PROJECT BRIEF 6-22
Grant or Contract Research for Bureau

1. Organization Performing Research: University of Pittsburgh.
2. Descriptive Project Title: Physical and Chemical Characterization of Respirable Coal Mine Dust
3. Objective of Project: Characterization of several physical and chemical properties of several mine dust samples.
4. Summary of Project Progress to Date: Large samples of respirable dust were collected and fractionated into subsizes. Such physical properties as density, projected area, surface area were determined for each size fraction. The size fractions were also analyzed chemically for normal coal properties and the occurrence of trace elements. No significant difference was noted in the characteristics of different size fractions of the same coal dust. A revised final report is being prepared.
5. Remaining Technological Deficiencies: More information is desired on methods to characterize subfractions of respirable dust.
6. Schedule and Project Funding: The project was started June 1971, completion was scheduled July 1972 and the project was essentially complete December 1972. The project was funded by the U.S. Bureau of Mines for \$81,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 18, 1973
Reviewed by Dr. W. Courtney, February 13, 1973

RESEARCH PROJECT BRIEF 6-23
Grant or Contract Research for Bureau

1. Organization Performing Research: Pennsylvania State University.
2. Descriptive Project Title: Method for Quantitative Characterization of Coal Mine Dust
3. Objective of Project: The objectives of the project were 1) to explore the usefulness of the scanning electron microscope for measuring size, mass, shape, and distribution of chemical elements in coal mine dust and 2) to explore the use of soft x-rays to estimate silica content of filter sample collected in the field.
4. Summary of Project Progress to Date: The scanning electron microscope has been developed to where particle size and shape and the distribution of elements and mass distribution of silica are automatically counted. The software and hardware for a soft x-ray machine to measure the free silica content of mine dust has been developed. The feasibility of using cathode luminescence and other technique for silica measurement are being evaluated.
5. Remaining Technological Deficiencies: This project is being operated in conjunction with the "in-house" program "Characterization of Mine Dust Particles" in which the Pennsylvania state developments are being evaluated, improved, and utilized.
6. Schedule and Project Funding: The project was started in June 1971 and has been extended twice. Completion is scheduled for June, 1974. The program is funded by the U.S. Bureau of Mines for \$222,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 18, 1973
Reviewed and revised by Dr. W. Courtney, February 13, 1973

RESEARCH PROJECT BRIEF 7-1
Research by Other Government Agencies

1. Organization Performing Research: MSA Research Corporation.
2. Descriptive Project Title: The Development of High Expansion Foam Systems for the Suppression of Respirable Dust
3. Objective of Project: The objective of the project was to develop the hardware and field test foam system on an auger head and ripper-type mining machine.
4. Summary of Project Progress to Date:

High expansion (350:1) soft detergent foams have been examined as a possible countermeasure to float dust in coal mines. Current mining operations and machines were first examined in terms of foam generation requirements. A subsequent laboratory development program evolved the foam formulation and hardware best suited for underground operations.

Preliminary field testing using dust samplers to evaluate performance indicate that foam can make a significant contribution to allaying dust generated from a 100L auger type miner. Results obtained with a ripper or rotating head type miner are inconclusive because of difficulties in the test run. Less than optimum use of foam can yield dust loadings considerably higher than existing dust suppressing methods.
5. Remaining Technological Deficiencies: Further development of spray systems for ripper-type continuous mining machinery is required.
6. Schedule and Project Funding: This project was completed April 1971. This project was funded by the Commonwealth of Pennsylvania, Department of Environmental Research, Bureau of Planning and Coal Research, for \$34,000.

Project Brief prepared by Bituminous Coal Research, Inc.
From reports supplied by Dr. D. E. Maneval

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RESEARCH PROJECT BRIEF 7-2
Research by Other Government Agencies

1. Organization Performing Research: MSA Research Corporation.
2. Descriptive Project Title: Development of High Expansion Foam System for the Suppression of Respirable Coal Dust
3. Objective of Project: To investigate the feasibility of using high expansion surfacant foam to contain or suppress the respirable dust generated by coal mining machinery at the coal face.
4. Summary of Project Progress to Date: Tests were run with foam equipment in the laboratory and tests were run at selected mines, on a twin auger unit, and with a fixed and oscillating head continuous mining machine. The tests are almost complete. The results obtained to date are promising and indicate that effective dust suppression may be possible with significantly less water.
5. Remaining Technological Deficiencies: NIOSH project officer feels that it is not appropriate to comment on this item since such projects will no longer be funded by the Industrial Hygiene Service Branch.
6. Schedule and Project Funding: This project was started in June 1971 and scheduled completion was June 1972; the project was extended after an equipment breakdown with additional funding. This project was funded by NIOSH for \$110,000 including the extension.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 23, 1973
Reviewed and revised by Mr. T. Anania, March 27, 1973

RESEARCH PROJECT BRIEF 7-3
Research by Other Government Agencies

1. Organization Performing Research: Commonwealth of Pennsylvania.
2. Description Project Title: Coal Handlers' Study
3. Objective of Project: The objective of the project was to obtain statistical data on the respiratory impairment of workers other than coal miners exposed to respirable coal dust.
4. Summary of Project Progress to Date: Environmental and physiological data have been obtained.
5. Remaining Technological Deficiencies: It appears that there are too many uncertainties to allow a realistic statistical evaluation. There are not enough workers in different age groups with known exposure to coal dust. Coal handling is often only one of many tasks performed by "coal handlers." Many coal handlers are former coal miners.
6. Schedule and Project Funding: The project was started June 1971 and scheduled for completion June 1973. The project is funded by NIOSH for \$168,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review December 18, 1972
Reviewed by Dr. G. Carson, January 4, 1973

RESEARCH PROJECT BRIEF 7-4
Research by Other Government Agencies

1. Organization Performing Research: Eastern Associated Coal Corporation.
2. Descriptive Project Title: To Evaluate Current Respirator Use in Underground Coal Mines
3. Objective of Project: To evaluate the performance and acceptance of currently available respirators.
4. Summary of Project Progress to Date: A survey of working coal miners indicated that current respirators are uncomfortable, make breathing difficult, restrict the miner's vision. The protection afforded by respirators covers a wide range depending on such factors as facial size, wearing time, and correct positioning of the mask.
5. Remaining Technological Deficiencies: It appears that it will be difficult to develop an efficient, low resistance, comfortable respirator.
6. Schedule and Project Funding: This is an 18 month project with a scheduled completion June 1973. The project was funded by NIOSH for \$150,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 21, 1973
Reviewed and revised by Mr. R. Lester, March 6, 1973

RESEARCH PROJECT BRIEF 7-5
Research by Other Government Agencies

1. Organization Performing Research: Synsis, Inc.
2. Descriptive Project Title: Performance Evaluation of Air Supplied Respirators for Underground Coal Mining
3. Objective of Project: To test and evaluate 10 prototype and production models of air supplied respirator systems.
4. Summary of Project Progress to Date: Ten relatively new systems were selected for testing. Units will be tested in the laboratory and later in high and low seam coal mines to determine performance and acceptability.
5. Remaining Technological Deficiencies: Reaction of miners to such equipment has yet to be determined. It is anticipated that machine operators will have difficulty utilizing the pack mounted units.
6. Schedule and Project Funding: This project is scheduled for completion December, 1973. This project is funded by NIOSH for \$83,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 21, 1973
Reviewed and revised by Mr. R. Lester, March 6, 1973

RESEARCH PROJECT BRIEF 7-6
Research by Other Government Agencies

1. Organization Performing Research: Atomic Energy Commission - LASL
2. Descriptive Project Title: Studies by LASL
3. Objective of Project: Test methods and equipment for more valid methods of approval testing and quality control testing of respirators are being developed.
4. Summary of Project Progress to Date: Work is progressing on the development of NaCl and polydisperse DOP test methods. Other quality control quick tests are also being investigated. Anthropometric measurements were performed on approximately 300 potential fit test subjects.
5. Remaining Technological Deficiencies: The NaCl and DOP test methods must be correlated with existing approval test methods. A fit test panel must be selected and tests performed to establish the validity of the panel. A respirator selection guide will be determined.
6. Schedule and Project Funding: This is a continuing effort which is renewed yearly as funds permit under an inter-agency agreement for research on respiratory devices.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 21, 1973
Reviewed and revised by Mr. R. Lester, March 6, 1973

RESEARCH PROJECT BRIEF 7-7
Research by Other Government Agencies

1. Organization Performing Research: Webb Associates.
2. Descriptive Project Title: Anthropological Research Related to Sizing and Fit of Respirators
3. Objective of Project: To develop anthropometric information which will be used to develop respirator sizing requirements and approval testing methods.
4. Summary of Project Progress to Date: Project to be started in March, 1973.
5. Remaining Technological Deficiencies: None reported.
6. Schedule and Project Funding: This project is scheduled for completion March 1974. This project is funded by NIOSH for \$30,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 21, 1973
Reviewed and revised by Mr. R. Lester, March 6, 1973

RESEARCH PROJECT BRIEF 7-8
Research by Other Government Agencies

1. Organization Performing Research: Synsis, Inc.
2. Descriptive Project Title: Study to Develop a Prototype Air Supplied Respirator for Use by Underground Coal Mining Equipment Operators.
3. Objective of Project: Same as title.
4. Summary of Project Progress to Date: Work is progressing on developing an electric or hydraulically driven respirator system with two stages of filtration.
5. Remaining Technological Deficiencies: Due to the fear of being tethered to a machine, the acceptance of such a system may create a use time lag.
6. Schedule and Project Funding: This is an 18 month project scheduled for completion June 1973. The project is funded by NIOSH for \$150,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 21, 1973
Reviewed and revised by Mr. R. Lester, March 6, 1973

RESEARCH PROJECT BRIEF 7-9
Research by Other Government Agencies

1. Organization Performing Research: University of Minnesota.
2. Descriptive Project Title: Evaluation of a Coal Mine Dust Personal Sampler Performance
3. Objective of Project: The objectives of the program are to determine the effects of particle charges, pump pulsations, pulsation dampening, inlet orientation and mass landing on the performance of the personal sampler.
4. Summary of Project Progress to Date: The effects of charging and pulsations have been determined, using mono and poly dispersed aerosols. Effects of orientation and mass loading are presently being determined.
5. Remaining Technological Deficiencies: It is expected that the effects of pulsation and mass loading will be answered definitively and the effects of charging and inlet orientation indicatively. Further evaluations of the effects of charges and orientation may therefore be necessary.
6. Schedule and Project Funding: The project was started June 1970 with completion scheduled for March 1973. The project is funded by NIOSH for a total of \$116,000, including extensions.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review December 18, 1972
Reviewed and revised by Dr. G. Carson, January 4, 1973

RESEARCH PROJECT BRIEF 7-10
Research by Other Government Agencies

1. Organization Performing Research: Bendix Corporation.
2. Descriptive Project Title: Development of Improved Coal Mine Dust Sampler
3. Objective of Project: Develop and manufacture a lapel-mounted personal dust sampler with lapel-mounted pump and belt-mounted battery pack.
4. Summary of Project Progress to Date: Hardware design complete and prototype ready for delivery.
5. Remaining Technological Deficiencies: Instrument has yet to be calibrated. Plans for calibration include "in-house" calibration by a contractor.
6. Schedule and Project Funding: The project was started June 1971 and completion was scheduled for December 1972. The project was funded by NIOSH for \$85,000 including an extension.

Project Brief prepared by Bituminous Coal Research, Inc.
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Reviewed and revised by Dr. G. Carson, January 4, 1973

RESEARCH PROJECT BRIEF 7-11
Research by Other Government Agencies

1. Organization Performing Research: Dynadyne Corporation.
2. Descriptive Project Title: Intermediate Volume Personal Sampler
3. Objective of Project: Design and build prototype of a personal sampler capable of collecting larger samples (large enough for subsequent chemical analysis). This sampler is intended for surface coal mines.
4. Summary of Project Progress to Date: Cyclone was specified in the contract. A pump mechanism has been selected. Details of battery pack and voltage control have not yet been finalized.
5. Remaining Technological Deficiencies: It will be difficult to keep the total weight close to the desired 7 lb limit but this weight goal appears realistic. It is intended that the prototype instrument developed will be calibrated "in-house" and by a contractor.
6. Schedule and Project Funding: The project was started June 1972, with completion scheduled for June 1973. This project is funded by NIOSH for \$28,000.

Project Brief prepared by Bituminous Coal Research, Inc.
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Reviewed by Dr. G. Carson, January 4, 1973

RESEARCH PROJECT BRIEF 7-12
Research by Other Government Agencies

1. Organization Performing Research: The Center for Air Environment Studies, Pennsylvania State University.
2. Descriptive Project Title: Develop Portable Particulate Counting Machine
3. Objective of Project: Was to develop a portable, permissible unit that would count and size respirable dust in preselected registers.
4. Summary of Project Progress to Date: A portable 14 lb, permissible, battery operated instrument has been developed. The original non-permissible instrument was tested in a variety of dust atmospheres including surface coal handling. The mine testing of a permissible unit is pending.
5. Remaining Technological Deficiencies: An effective dilution device is needed to allow adequate size and particle number discrimination in high dust concentrations.
6. Schedule and Project Funding: The specific funds for the project have been exhausted.

The development was funded by the Commonwealth of Pennsylvania Department of Environmental Research, Bureau of Planning and Coal Research for \$60,000. The project is presently being completed with University funding.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 21, 1973
Reviewed and revised by Dr. W. Moroz, February 27, 1973

RESEARCH PROJECT BRIEF 7-13
Research by Other Government Agencies

1. Organization Performing Research: GCA Corporation.
2. Descriptive Project Title: Coal Mine Dust Instantaneous Mass Monitor
3. Objective of Project: The objective of the project was to develop a fast reading instrument for determining dust concentrations in a coal mine.
4. Summary of Project Progress to Date: A prototype instrument has been delivered.
5. Remaining Technological Deficiencies: The performance of this instrument needs to be evaluated under laboratory conditions.
6. Schedule and Project Funding: The project was started June 1970 and completed June 1972. The project was funded by NIOSH for \$36,000. There is additional funding by the manufacturer and other organizations using this device experimentally.

Project Brief prepared by Bituminous Coal Research, Inc.
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Reviewed by Dr. G. Carson, January 4, 1973

RESEARCH PROJECT BRIEF 7-14
Research by Other Government Agencies

1. Organization Performing Research: New York University.
2. Descriptive Project Title: Cyclone Performance Evaluation
3. Objective of Project: Evaluation of performance characteristics of 2-inch, 1-inch, and 3/4-inch cyclones.
4. Summary of Project Progress to Date: Evaluation is complete and final report is being prepared.
5. Remaining Technological Deficiencies: The penetration data for three cyclones has been obtained at the air rates specified.
6. Schedule and Project Funding: The project was started June 1971 and scheduled for completion December 1972. The project was funded by NIOSH for \$29,000.

Project Brief prepared by Bituminous Coal Research, Inc.
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Reviewed and revised by Dr. G. Carson, January 4, 1973

RESEARCH PROJECT BRIEF 7-15
Research by Other Government Agencies

1. Organization Performing Research: New York University.
2. Descriptive Project Title: Coal Mine Dust Mass Distribution Study
3. Objective of Project: The objective of the project was to develop the multicyclone aerosol sampler for in-mine use to determine the size mass distribution of coal dust in underground mines.
4. Summary of Project Progress to Date: The development has been completed and a final report submitted.
5. Remaining Technological Deficiencies: The prototype sampler needs to be redesigned by a manufacturer of industrial instruments.
6. Schedule and Project Funding: The project was started June 1970 and completed June 1972. The program was funded by NIOSH for \$26,000.

Project Brief prepared by Bituminous Coal Research, Inc.
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Reviewed by Dr. G. Carson, January 4, 1973

RESEARCH PROJECT BRIEF 7-16
Research by Other Government Agencies

1. Organization Performing Research: Atomic Energy Commission (LASL).
2. Descriptive Project Titles: Aerosol Studies and Sampler Development
3. Objective of Project: There are three objectives to the present program:
 - a. Develop a standard dust from bulk coal.
 - b. Develop a dynamic coal dust chamber.
 - c. Develop different ways of generating coal dust.
4. Summary of Project Progress to Date: Procedures are being developed to produce standard dust samples. Delivery of the samples is expected in June. The first dynamic coal dust unit is being evaluated "in-house" by NIOSH and a second improved unit is expected in December 1972. Concepts for generating coal dust in different ways are being evaluated.
5. Remaining Technological Deficiencies: It is expected that the standard dust samples and the revised dynamic coal dust chamber will be adequate for the routine testing of dust sampling devices at the Appalachian Laboratory for Occupational Respiratory Diseases.
6. Schedule and Project Funding: The project is a continuing program that is renewed annually. The schedule is different for each research topic. The program is funded under an inter-agency agreement for research in industrial dust. The estimated expenditure on coal dust in 1972 is \$50,000.

Project Brief prepared by Bituminous Coal Research, Inc.
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Reviewed and revised by Dr. G. Carson, January 4, 1973

RESEARCH PROJECT BRIEF 7-17
Research by Other Government Agencies

1. Organization Performing Research: NIOSH
2. Descriptive Project Title: Evaluation of Instruments to Measure Concentration of Respirable Coal Dust
3. Objective of Project: The objective of this project is to develop equipment to produce dust clouds suitable for the evaluation of dust samplers and to evaluate dust samplers and their components.
4. Summary of Project Progress to Date: The first dynamic dust chamber has been modified to where reproducible flowing dust clouds can be produced. An effective laboratory dust tunnel with a generator of monosize aerosols has also been developed. Data available to date indicate that the 10 mm personal cyclone is an accurate and reliable component in a personal dust sampler.
5. Remaining Technological Deficiencies: There is a need to obtain more definitive evaluations of such effects as inlet orientation, ambient humidity, total dust loading, lowering battery voltage, motion of cyclone, etc., on the performance of a personal sampler.
6. Schedule and Project Funding: This project is a continuing NIOSH "in-house" program. This section operates on a total budget which is not broken down between coal and other industrial dust and between in-house research and servicing of contracts.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review December 18, 1972
Reviewed by Dr. G. Carson, January 4, 1973

RESEARCH PROJECT BRIEF 9-1
Research by Industry

1. Organization Performing Research: Peabody Coal Company - Ledgemont Laboratory.
2. Descriptive Project Title: Model Study of Mine Ventilation
3. Objective of Project: To study the ventilation systems of underground coal mines.
4. Summary of Project Progress to Date: A 1/40th scale model of significant portions of the ventilation system of the No. 10 mine at Pawnee, Illinois, has been built. Tests have been conducted using clean air to determine air flows. Details of results are confidential.
5. Remaining Technological Deficiencies: Details confidential.
6. Schedule and Project Funding: Schedule is confidential. This program is funded by Kennecott Copper Corporation.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 12, 1973
Reviewed and revised by Dr. J. Campbell, March 16, 1973

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RESEARCH PROJECT BRIEF 9-2
Research by Industry

1. Organization Performing Research: Peabody Coal Company - Ledgemont Laboratory.
2. Descriptive Project Title: Model Study of Face Area
3. Objective of Project: To investigate the flow at the face with blowing ventilation to determine how best to minimize dust emission.
4. Summary of Project Progress to Date: A 1/10 scale model of a typical face in high coal was built. Tests have been conducted using clean air to determine flow patterns at the face. Details of results are confidential.
5. Remaining Technological Deficiencies: The momentum of the ventilating air in blowing systems results in higher turbulence at the face than in a comparable exhausting system and a greater tendency to contaminate the operator's breathing air. Blowing systems are, however, preferred in certain quarters as inherently safer and the technology for minimizing the dust emission for such system has to be developed.
6. Schedule and Project Funding: This project is funded by Kennecott Copper Corporation.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 12, 1973
Reviewed and revised by Dr. J. Campbell, March 16, 1973

RESEARCH PROJECT BRIEF 9-3
Research by Industry

1. Organization Performing Research: Peabody Coal Company - Ledgemont Laboratory.
2. Descriptive Project Title: Test of Scrubbers
3. Objective of Project: To build a test facility to aid in the development of improved scrubbers for dust suppression.
4. Summary of Project Progress to Date: A 1 ft diameter dust tunnel has been built. Tests are being undertaken of scrubbers of in-house design. Details of results are confidential.
5. Remaining Technological Deficiencies: Details confidential.
6. Schedule and Project Funding: Schedule is confidential. This program is funded by Kennecott Copper Corporation.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 12, 1973
Reviewed and revised by Dr. J. Campbell, March 16, 1973

RESEARCH PROJECT BRIEF 9-4
Research by Industry

1. Organization Performing Research: Donaldson Company Inc.
2. Descriptive Project Title: Development of Dust Separator for In-Mine Use
3. Objective of Project: The objective of the project is to work with equipment manufacturers to enable the optimum use of Donaldson panels in miner-mounted scrubbers and suction fans.
4. Summary of Project Progress to Date: Donaldson panels have been successfully integrated with several wet scrubbing systems.
5. Remaining Technological Deficiencies: For separate suction fans, more development is needed in the disposal of the scrubbed liquid. The development of scrubbing systems mounted on mining machines is stalled because of overriding concern for the hazard involved in changing ventilation patterns.
6. Schedule and Project Funding: Since the Donaldson Company Inc. became involved in the in-mine use of their equipment in mid-1971, they have spent \$73,000 of their own funds; manufacturers have contributed an additional \$30,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 17, 1973
Reviewed by Mr. F. Stedman, January 23, 1973

RESEARCH PROJECT BRIEF 9-5
Research by Industry

1. Organization Performing Research: Donaldson Company Inc.
2. Descriptive Project Title: Development of System to Produce Respirable Exhaust
3. Objective of Project: To develop a wet air cleaner capable of producing an exhaust with less than 2 mg/m³ respirable dust content.
4. Summary of Project Progress to Date: Small-scale experiments have been conducted on an innovative device that significantly increases the agglomeration of the dust prior to entering into a normal Donaldson separator.
5. Remaining Technological Deficiencies: This approach appears technologically feasible. Further development will require outside funds to supplement the Donaldson money available for such a development.
6. Schedule and Project Funding: Since the Donaldson Company Inc. became involved in the in-mine use of their equipment in mid-1971, they have spent \$73,000 of their own funds; manufacturers have contributed an additional \$30,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 17, 1973
Reviewed by Mr. F. Stedman, January 23, 1973

RESEARCH PROJECT BRIEF 9-6
Research by Industry

1. Organization Performing Research: Conoco.
2. Descriptive Project Title: Underground Tests of Experimental Hydraulic Mining Equipment
3. Objective of Project: The objective of the project was to evaluate certain hydraulic mining parameters by operating a hydraulic mining machine underground.
4. Summary of Project Progress to Date: A battery of nozzles and the necessary auxiliary equipment were mounted on a Joy miner. The miner was moved underground to the Humphrey No. 7 mine (Christopher Division) and tested under a variety of settings. Data were collected, including data on dust and noise emissions (assistance provided by U.S. Bureau of Mines). The data have been used to evaluate the best condition for hydraulic coal mining. Detailed evaluation of the data is withheld since the tests involve the use of proprietary equipment.
5. Remaining Technological Deficiencies: Handling required water is a major problem but cutting efficiency remains at 7-10 times that of mechanical mining.
6. Schedule and Project Funding: The tests were started August 1971 and evaluation was completed August 1972. The estimated research costs are: Conoco \$100,000; Christopher Division of Consolidation Coal \$5,000; and Bendix Corporation \$2,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 4, 1973
Reviewed and revised by Dr. D. Dahl, January 25, 1973

RESEARCH PROJECT BRIEF 9-7
Research by Industry

1. Organization Performing Research: T. J. Gundlach Machine Company.
2. Descriptive Project Title: Development of 16 SC Scrubber
3. Objective of Project: The objective of the project was to develop and field test a miniscrubber with a discharge that would be ducted.
4. Summary of Project Progress to Date: A scrubber with a slightly smaller rotor than the 22 SC and the same overall dimensions, has been designed with a scroll-type housing. This scrubber develops a sufficient static pressure to allow the products to be discharged through a duct to the end of the machine. Field testing of this scrubber is now underway.
5. Remaining Technological Deficiencies: The 16 SC is a small scrubber suitable for either troublesome locations or as one of a multiple unit installation.
6. Schedule and Project Funding: This development is part of the corporate program of scrubber development that has cost an estimated \$250,000 since 1969.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 22, 1973
Reviewed and revised by Mr. T. F. Gundlach, April 18, 1973

RESEARCH PROJECT BRIEF 9-8
Research by Industry

1. Organization Performing Research: T. J. Gundlach Machine Company.
2. Descriptive Project Title: Development of 22 SC Miniscrubber
3. Objective of Project: The purpose of the project was to develop and field test a small scrubber.
4. Summary of Project Progress to Date: A merchandisable scrubber was developed which draws dust-laden air from the front of the mining machine, past the water spray, and the impingement type rotor. The air, water, and wetted and agglomerated dust are discharged on the loading pan of the machine. Some 15 of these units have been placed in field service without guarantee of performance, and it is expected that this scrubber will find acceptance for several applications where discharge is not required through a duct.
5. Remaining Technological Deficiencies: Recognizing that this machine has some limitations, particularly in the discharge of a reasonable volume of air through a duct, it was decided that a Model 30 SC Scrubber would be developed to handle a much larger volume of air and be designed in such a manner to discharge this volume through an extended length of ducting. Recognizing that there also is a need for a unit of small physical specifications, the Model 16 SC Scrubber was developed to fit within the physical limitations of the 22 SC but have the capability of handling a larger volume of air and discharging through an extended duct.
6. Schedule and Project Funding: This development is part of the corporate program of scrubber development that has cost an estimated \$250,000 since 1969.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 22, 1973
Reviewed and revised by Mr. T. F. Gundlach, April 18, 1973

RESEARCH PROJECT BRIEF 9-9
Research by Industry

1. Organization Performing Research: T. J. Gundlach Machine Company.
2. Descriptive Project Title: Development of 30 SC Scrubber
3. Objective of Project: The objective of the project was to develop and field test a high capacity scrubber capable of drawing dust laden air in at the front of the miner and discharging clean air at the rear.
4. Summary of Project Progress to Date: The 30 SC Scrubber has been developed to where it can be merchandized and guaranteed. This machine can be supplied as an add-on unit or be designed as an integral part of the machine.
5. Remaining Technological Deficiencies: This machine effects essentially total removal of visible dust and high removal of respirable dust.
6. Schedule and Project Funding: This development is part of the corporate program of scrubber development that has cost an estimated \$250,000 since 1969.

Project Brief prepared by Bituminous Coal Research, Inc.

Submitted for review January 22, 1973

Reviewed and revised by Mr. T. F. Gundlach, April 18, 1973

RESEARCH PROJECT BRIEF 9-10
Research by Industry

1. Organization Performing Research: T. J. Gundlach Machine Company.
2. Descriptive Project Title: Development of Rose Valley Type of Scrubber
3. Objective of Project: To develop a scrubber capable of removing both the respirable and float dust from mine air, and subsequently directing the clean air back toward the face along the ribs in an area close to the mine floor to prevent the boilling from cutter head rotation moving back along the floor toward the operator.
4. Summary of Project Progress to Date: The first miner-mounted scrubber gave encouraging results, demonstrating that dust reductions occurred when tested at Rose Valley Mine. It also removed the large percentage of float dust making the face visible for the first time to the miner operator. The scrubber included a scrubber mixing rotor and subsequent clean air separator, and two exhaust ducts directing the air over the side of the mining machine back toward the face. Being normally within ten feet of the face, the scrubber does no more than process the air in a manner similar to the processing carried on by the rotating cutter head. If processing of the air near the face becomes an acceptable way to operate a scrubber, the design of this scrubber should be further evaluated.

Review of this scrubber operation led to the thinking that it may not be necessary to separate the dust laden water from the air but rather that the affluent would be discharged directly without separation. As a result the Model 22 SC Scrubber was developed.
5. Remaining Technological Deficiencies: It has been decided that the rotor used in this type of scrubber will require additional design work to become commercially available.
6. Schedule and Project Funding: This development is part of the corporate program of scrubber development that has cost an estimated \$250,000 since 1969.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 22, 1973
Reviewed and revised by Mr. T. F. Gundlach, April 18, 1973

RESEARCH PROJECT BRIEF 9-11
Research by Industry

1. Organization Performing Research: Old Ben Coal Corp.
2. Descriptive Project Title: Test of Sprays and Development of Improved Spraying Systems for Mine Machines
3. Objective of Project: To test various commercially available sprays and to adapt the more successful sprays into spraying system that would improve the suppression of dust from their various miner machines.
4. Summary of Project Progress to Date: Four different types of sprays were investigated. Some 500 spray nozzles were purchased and placed in various arrangements on their mining machines. Some arrangements were developed that considerably improved the emission of visible dust but the suppression of respirable dust by sprays alone was not significant.
5. Remaining Technological Deficiencies: The Old Ben Coal Corporation retained the use of water sprays but have not yet been able to develop additional means of reducing the respirable dust levels at the operators' stations.
6. Schedule and Project Funding: This project is complete; it cost \$3,000 (equipment only).

Project Brief prepared by Bituminous Coal Research, Inc.

Submitted for review January 25, 1973

Reviewed and revised by Mr. P. Bailie, April 17, 1973

RESEARCH PROJECT BRIEF 9-12
Research by Industry

1. Organization Performing Research: Old Ben Coal Corp.
2. Descriptive Project Title: Extended Underground Test of Deron Air Water Spray Systems for Dust Suppression on Mining Machines
3. Objective of Project: The objective of the test was to equip several Goodman borers and a ripper continuous miner with a series of Deron sprays for extensive underground testing.
4. Summary of Project Progress to Date: Two sets of Deron sprays and air compressors were installed on 2 Goodman borers. Results of initial tests indicated compliance with 3 mg/m³ standard and in pillar work the 2.0 mg/m³ standard could be met. Ten additional compressors were ordered along with Deron sprays. Improvement is significant on boring type miners but no significant improvement was noted on ripper type miners. Deron sprays are still being used on the boring type units.
5. Remaining Technological Deficiencies: Primary problem is that the mist made by the sprays on occasions causes a visibility problem right at the face giving operators some difficulty in observing cutter head position.
6. Schedule and Project Funding: This project is continuing. The project cost was \$50,000 to date (equipment only).

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 25, 1973
Reviewed and revised by Mr. P. Bailie, April 17, 1973

RESEARCH PROJECT BRIEF 9-13
Research by Industry

1. Organization Performing Research: Old Ben Coal Corp.
2. Descriptive Project Title: Test of Low Resistance Exhaust Tubing
3. Objective of Project: The objective of the test was to evaluate the prospects of using exhaust tubing for face ventilation and dust removal at the Old Ben Mines in Illinois.
4. Summary of Project Progress to Date: Some 2,000 feet of flexible tubing, 14, 16, and 20 in. diameter was purchased. Some ovalized tubing was supplied for testing by the U.S. Bureau of Mines. Some 500 ft of PVC rigid tubing was also purchased to use with 25 and 30 hp fans. It was found that 14 and 16 in. flexible tubing could not handle adequate air volumes to meet the 2.0 mg/m³ standard on boring miners. The ovalized tubing was structurally weak and collapsed under suction. The 20 in. flexible was too large to haul under. The rigid tubing appeared to handle reasonable air volumes but its weight, fit, and hangability made it impractical. Further tests are planned with a new lighter weight rigid tubing.
5. Remaining Technological Deficiencies: It is felt that ventilation with supplementary exhaust fans will require tubing with low friction resistance.
6. Schedule and Project Funding: These tests will continue as long as new types of tubing, such as the lightweight semi-rigid tubing, are available. This project was funded by the Old Ben Coal Corp. for \$12,000 to date for tubing only. Costs due to production losses during tests are not available.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 25, 1973
Reviewed and revised by Mr. P. Bailie, April 17, 1973

RESEARCH PROJECT BRIEF 9-14
Research by Industry

1. Organization Performing Research: Old Ben Coal Corp.
2. Descriptive Project Title: Belt Entry Clean Up
3. Objective of Project: The objective of the project was to examine the effectiveness of scrubbers to reduce both float dust and respirable dust in suspension at belt transfer points and along the belt lines.
4. Summary of Project Progress to Date: A respirable dust content up to 2.0 mg/m^3 was detected along certain belt lines. It was concluded that some of this problem was due to dust generation at belt transfer points despite the use of sprays. A Joy and Jeffrey scrubber have been ordered for installation at belt transfer points from which some apparent float dust is generated.
5. Remaining Technological Deficiencies: A reduction in the respirable and float dust content along belt lines in itself will not bring sections into compliance with the 2.0 mg/m^3 standard but float dust along belt should be considerably improved. Men who work in these areas will also receive benefits from this project by the reduction of respirable dust.
6. Schedule and Project Funding: Installation and evaluation of the scrubbers is expected to be completed August 1, 1973. This project is funded by the Old Ben Coal Corporation for \$7,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 25, 1973
Reviewed and revised by Mr. P. Bailie, April 17, 1973

RESEARCH PROJECT BRIEF 9-15
Research by Industry

1. Organization Performing Research: Old Ben Coal Corp.
2. Descriptive Project Title: Test of Gundlach 22 SC Mini-scrubbers on Goodman Boring Machine
3. Objective of Project: The objective of the project was to test two mini-scrubbers located on Goodman boring machine in accessible high dust locations.
4. Summary of Project Progress to Date: The design and operation of the Goodman borer was carefully studied to determine the best location for scrubbers. Acceptable locations were found for two mini-scrubbers. The machine was tested for 30 shifts. Little improvement in respirable dust concentrations was noted. The scrubbing capacity of the mini-scrubbers was not high enough to give significant improvement.
5. Remaining Technological Deficiencies: The Goodman borer is a machine Old Ben feels is well suited for 96 inch coal because of its operational availability as well as its entry configuration which is basically a more stable cross sectional area. There appears, however, to be no suitable space for a physically larger scrubber on this unit. Since Old Ben Coal Corporation is one of the last major operators to use this machine, they cannot expect to receive a lot of benefit from developments by others.
6. Schedule and Project Funding: This mini-scrubber test program has been completed. This project cost the Old Ben Coal Corp. \$8,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 25, 1973
Reviewed and revised by Mr. P. Bailie, April 17, 1973

RESEARCH PROJECT BRIEF 9-16
Research by Industry

1. Organization Performing Research: Old Ben Coal Corp.
2. Descriptive Project Title: Test of Gundlach 30 SC Scrubber for Continuous Miner
3. Objective of Project: To install a Gundlach 30 SC scrubber on a continuous miner and test for dust suppression under normal mining conditions.
4. Summary of Project Progress to Date: A Gundlach 30 SC scrubber was ordered but the manufacturer suggested that he delay fabrication pending the review of scrubber operation.
5. Remaining Technological Deficiencies: It remains to be determined whether the scrubber and associated ductwork will enable compliance with the 2.0 mg/m³ dust limit in one pass mining using blowing ventilation.
6. Schedule and Project Funding: The schedule is uncertain but the Old Ben Coal Corp. expects to proceed with the purchase of this scrubber as soon as their operation is allowed. It is expected that this test program will cost \$15,000 for equipment and installation only.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 25, 1973
Reviewed and revised by Mr. P. Bailie, April 17, 1973

RESEARCH PROJECT BRIEF 9-17
Research by Industry

1. Organization Performing Research: Old Ben Coal Corp.
2. Descriptive Project Title: Test of Scrubber Using Donaldson Panel Built into Jeffrey Continuous Miner
3. Objective of Project: To test the Jeffrey design of scrubber under many conditions to determine its effectiveness for dust suppression.
4. Summary of Project Progress to Date: The machine was operated for one week. The operation appeared promising but no systematic dust measurements were made. The tests were suspended along with most other scrubber tests due to the Bureau's position on scrubbers at that time. Tests will be made on the scrubber as soon as a permit can be obtained for its operation.
5. Remaining Technological Deficiencies: It remains to be determined whether the scrubber and associated ductwork will enable compliance with the 2.0 mg/m^3 dust limit in one pass mining using blowing ventilation.
6. Schedule and Project Funding: The schedule is uncertain but the Old Ben Coal Corp. expects to proceed with the test. It is expected that this test program will cost \$18,000 to \$20,000 for equipment and installation. Costs for lost production during the test program is not known.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 25, 1973
Reviewed and revised by Mr. P. Bailie, April 17, 1973

RESEARCH PROJECT BRIEF 9-18
Research by Industry

1. Organization Performing Research: Old Ben Coal Corp.
2. Descriptive Project Title: Economic Evaluation of the Use of Cryogenic Air Supply for Equipment Operators
3. Objective of Project: The objective of this project was to cooperate with Essex Criogenic to obtain realistic figures of the cost of supplying "criogenic air" to the operators at three mines.
4. Summary of Project Progress to Date: The cost of setting up a central plant to produce liquid air and distribute it for use in separate breathing units for individual operators was investigated. It was determined that if such a system were the principal system of dust control, it would be economical.
5. Remaining Technological Deficiencies: The acceptability of individual breathing units has not been established but ready acceptance is expected. Despite the fact that supply 0 mg/m^3 air to the operator does not result in compliance with statutory dust limits, the system is still an effective means of safeguarding the health of coal miners.
6. Schedule and Project Funding: This study is complete. The cost of the study by the Old Ben Coal Corp. was \$2500.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 25, 1973
Reviewed and revised by Mr. P. Bailie, April 17, 1973

RESEARCH PROJECT BRIEF 9-19
Research by Industry

1. Organization Performing Research: Freeman Coal Company.
2. Descriptive Project Title: Test of Wetting Agents
3. Objective of Project: To test for improved dust suppression by adding selected wetting agents to the spray water used on a mining machine.
4. Summary of Project Progress to Date: Four wetting agents were tested during otherwise normal mining operation. Wetting agents produced some reduction in visible dust but no measurable reduction in respirable dust.
5. Remaining Technological Deficiencies: There appears little promise of substantially reducing respirable dust emissions by using wetting agents with the spray water.
6. Schedule and Project Funding: The project was completed 1972. The project cost \$1,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 26, 1973
Reviewed and revised by Mr. M. Harrell, February 19, 1973

RESEARCH PROJECT BRIEF 9-20
Research by Industry

1. Organization Performing Research: Freeman Coal Company.
2. Descriptive Project Title: Test of Steam for Dust Suppression
3. Objective of Project: To evaluate wet steam as an alternate to water sprays for dust suppression.
4. Summary of Project Progress to Date: A steam generator and piping were mounted on a continuous mining machine. The machine was tested underground. Measurement of dust concentrations indicated that steam was no better than water sprays for dust suppression.
5. Remaining Technological Deficiencies: There appears to be no justification for proceeding with evaluations of steam for dust suppression. Data later published for concurrent tests substantiated this opinion.
6. Schedule and Project Funding: This project has been completed. The project cost \$1,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 26, 1973
Reviewed and revised by Mr. M. Harrell, February 19, 1973

RESEARCH PROJECT BRIEF 9-21
Research by Industry

1. Organization Performing Research: Freeman Coal Company.
2. Descriptive Project Title: Test of Compressed Air and Water Mixture on Face Machines
3. Objective of Project: To evaluate the results of using a mixture of air at 100 psig and water sprays at 100 lbs pressure in place of water sprays alone, as normally used on our mining machines.
4. Summary of Project Progress to Date: A small compressor was set up two crosscuts from the face, with an air hose leading from it to the 45E Lee-Norse miner at the face. In two weeks of testing, the water sprays were shifted periodically to find suitable position where adequate performance of atomized water sprays would result. Visible improvement took place from the introduction of the compressed air, and a good blanket of fine misty fog was produced but no significant change in respirable dust count was accomplished.
5. Remaining Technological Deficiencies: Since the Lee-Norse is an oscillating machine and lacks a fixed mining height, the sprays could not be positioned where they had a movable or variable coverage to coincide with the cyclic movement of the cutting head. Procedure does not appear practical for this type of machine.
6. Schedule and Project Funding: Completed in 1972. The project cost \$2,000.

Project Brief prepared February 19, 1973, by Mr. M. Harrell

RESEARCH PROJECT BRIEF 9-22
Research by Industry

1. Organization Performing Research: Freeman Coal Company.
2. Descriptive Project Title: Test of Face Ventilation with Both Exhaust and Blowing Tubings
3. Objective of Project: To test the improvement in dust suppression by adding exhaust tubing and fan to the normal blowing ventilation system.
4. Summary of Project Progress to Date: A 25 hp fan was installed in the return and connected to 24 in. diameter tubing that was located behind the mining machine. A noticeable reduction in respirable dust was obtained but there is not adequate room for two ventilation tubings, power cable, water line, in the 14 ft rooms.
5. Remaining Technological Deficiencies: The work involved in maintaining the exhaust tubing and the manpower required to maintain it close to the mining machine made this feasible concept impractical and uneconomical.
6. Schedule and Project Funding: This project was completed 1972. The cost was \$11,000, not including a contribution in manpower and equipment by the U.S. Bureau of Mines.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 26, 1973
Reviewed and revised by Mr. M. Harrell, February 19, 1973

RESEARCH PROJECT BRIEF 9-23
Research by Industry

1. Organization Performing Research: Freeman Coal Company.
2. Descriptive Project Title: Test of Foam for Dust Suppression
3. Objective of Project: To test MSA foam emitted near the cutter as a means of dust suppression.
4. Summary of Project Progress to Date: Foam generating equipment was installed on a 48H Lee-Norse and a 45E Lee-Norse mining machine. The machines were tested under mining conditions to determine the effectiveness of foam for dust suppression. The tests indicated that persistent foam could be spread in the whole working area but that the foam was rapidly dispersed from the cutting area and did not have any significant dust suppressing capabilities.
5. Remaining Technological Deficiencies: Foam is being more systematically tested elsewhere.
6. Schedule and Project Funding: The project was completed 1968. The project cost \$2,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 26, 1973
Reviewed and revised by Mr. M. Harrell, February 19, 1973

RESEARCH PROJECT BRIEF 9-24
Research by Industry

1. Organization Performing Research: Freeman Coal Company.
2. Descriptive Project Title: Test of Miner Mounted Scrubbers
3. Objective of Project: To test the dust suppression of two of the latest scrubbers mounted on continuous mining machines.
4. Summary of Project Progress to Date: A Jeffrey miner fitted with a Jeffrey fan and Donaldson panel and a Lee-Norse miner fitted with a scrubber and fan of Lee-Norse design, have been purchased. These miners will be tested under mining conditions as soon as the use of such scrubbers is authorized.
5. Remaining Technological Deficiencies: It is expected that both these scrubbers will improve face visibility, reduce the ambient concentration of visible dust, and reduce the dust concentration in the returns. It is doubted that these first generation scrubbers will produce 2.0 mg/m^3 respirable dust concentration at the operator's station. Recirculation inherent in such installations is not considered a problem at these installations because methane outputs are low and secondary air movement should not be able to reduce the rate of fresh air admission to the face in a system of blowing ventilation.
6. Schedule and Project Funding: \$8,000 and \$9,000 respectively for cost new, to be mounted on machines named. No estimate made for costs while testing in the mine. Machines scheduled for production by mid 1973.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 26, 1973
Reviewed and revised by Mr. M. Harrell, February 19, 1973

RESEARCH PROJECT BRIEF 9-25
Research by Industry

1. Organization Performing Research: Freeman Coal Company.
2. Descriptive Project Title: Test of Wide Room Mining
3. Objective of Project: The objective of the project was to determine if the coals in the active Freeman properties could be mined using wider rooms that could accommodate exhaust ventilation.
4. Summary of Project Progress to Date: A section with roof conditions considered above average was developed using 20 ft wide rooms. There were six minor roof falls during this trial, indicating that the present 14 ft limit should not be exceeded.
5. Remaining Technological Deficiencies: The use of wider rooms and exhaust ventilation is the means that the producers feel would be most promising for obtaining the 2.0 mg/m³ environment for the machine operator. It does not appear that such wide room development can be considered for Freeman mines.
6. Schedule and Project Funding: The project was completed 1970. Cost \$15,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 26, 1973
Reviewed and revised by Mr. M. Harrell, February 19, 1973

RESEARCH PROJECT BRIEF 9-26
Research by Industry

1. Organization Performing Research: Freeman Coal Company.
2. Descriptive Project Title: Evaluation of Dust Control Technology
3. Objective of Project: To evaluate the applicability of available and developing dust control technology to the condition in narrow room mining.
4. Summary of Project Progress to Date: Visited numerous mining installations, the NCB MRDE at Bretby and several mines in the United Kingdom. No techniques suitable for reducing dust emissions in narrow rooms were discovered. It was also noted that the apparent dust conditions in the U.K. mines were worse than those existing in several U.S. mines that were not in compliance with the 3.0 mg/m³ limit.
5. Remaining Technological Deficiencies: Since the Freeman Coal Company is not constituted to perform original research, it must depend upon development by others to solve the dust problems.
6. Schedule and Project Funding: The program is continuing. Cost in 1971 and 1972 \$25,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 26, 1973
Reviewed and revised by Mr. M. Harrell, February 19, 1973

RESEARCH PROJECT BRIEF 9-27
Research by Industry

1. Organization Performing Research: Ziegler Coal Company.
2. Descriptive Project Title: Test of Miner-mounted Gundlach Scrubbers
3. Objective of Project: Test under mining conditions the dust clean-up effected by two prototype Gundlach 22 SC mini scrubbers installed on a Lee-Norse continuous miner.
4. Summary of Project Progress to Date: Two prototype Gundlach 22 SC mini-scrubbers were mounted on a Lee-Norse continuous miner. Preliminary tests indicated some improvement in the emission of visible dust. There was a mechanical breakdown of the equipment before systematic dust measurements could be made. Scrubber testing was suspended before the units were put back in service.
5. Remaining Technological Deficiencies: It is anticipated that these scrubbers will be superseded by larger scrubbers when scrubber testing is again permitted.
6. Schedule and Project Funding: There are no plans to resume these tests. It is corporate policy not to reveal such specific costs.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 22, 1973
Reviewed and revised by Mr. F. Dillard, April 3, 1973

RESEARCH PROJECT BRIEF 9-28
Research by Industry

1. Organization Performing Research: Ziegler Coal Company.
2. Descriptive Project Title: Test of Factory Designed Scrubber Installed on a Jeffrey Heliminer
3. Objective of Project: To test a scrubbing system of Jeffrey design for its effectiveness in dust suppression.
4. Summary of Project Progress to Date: The tests were being undertaken at the Ziegler No. 9 mine at Madisonville, Ky. During the initial testing there was an ignition at the face but no injuries. Operation was stopped and the incident was reported. An investigation was conducted. It was determined that the methane monitor was in operation but had not stopped the machine. Subsequently, the U.S. Bureau of Mines, May 23, 1972, memorandum was put out restricting further use of scrubbers. Further testing will be conducted when it is permitted.
5. Remaining Technological Deficiencies: It is expected that this scrubber will reduce the dust levels but it is not known whether it will enable dust reduction to 2.0 mg/m^3 at the operators' station on this miner. At this mine the miner is used principally for construction, and dust control is therefore more difficult because of the varied applications.
6. Schedule and Project Funding: The schedule for the resumption of these tests is uncertain. It is corporate policy not to reveal such specific costs.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 22, 1973
Reviewed and revised by Mr. F. Dillard, April 3, 1973

RESEARCH PROJECT BRIEF 9-29
Research by Industry

1. Organization Performing Research: Ziegler Coal Company.
2. Descriptive Project Title: Comparison of Continuous Versus Conventional Mining
3. Objective of Project: To evaluate whether the new mine should use predominantly continuous or conventional mining.
4. Summary of Project Progress to Date: It was decided that it would be more economical to operate the new mine principally with conventional mining units, using continuous miners principally for construction. The factors involved in the evaluation included higher labor cost for conventional mining, available former miners generally had continuous miner experience, compliance with 2.0 mg/m³ dust standards feasible in conventional units, coal was somewhat hard for available miners, selective mining more feasible in conventional mining. Compliance with 2.0 mg/m³ was a factor in the decision but the main factor was better product control for power plant coal to be delivered "raw."
5. Remaining Technological Deficiencies: The operators still have to determine how they will meet dust level requirements on their continuous miners used for construction.
6. Schedule and Project Funding: It is corporate policy not to reveal such specific costs.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 22, 1973
Reviewed and revised by Mr. F. Dillard, April 3, 1973

RESEARCH PROJECT BRIEF 9-30
Research by Industry

1. Organization Performing Research: Inland Steel.
2. Descriptive Project Title: Extended Field Test of ENJAY 7-9607 Dust Suppression Agent Added to Spray Water
3. Objective of Project: The objective of the project is to operate one section of the mine for one month with water only sprays and for two months using the proprietary agent added to the spray water.
4. Summary of Project Progress to Date: The section has been operated for one month using water only sprays. Dust samples were collected daily at selected stations. Tests with the anionic additive have been more encouraging than expected--an improvement of at least 23 percent is apparent from the initial tests. Further testing including cooperative testing with the Bureau is being considered.
5. Remaining Technological Deficiencies: The addition of additives presents no serious technical difficulties.
6. Schedule and Project Funding: The initial tests are approaching completion. Plans for future tests are indefinite but such tests will probably be made. Direct costs to date are detailed below.

Item	Cost
Chemical Injection Pump	\$ 1,117.00
Chemical (borne by ENJAY)	--
Set up, replacements, repairs	277.37
Cassettes	375.00
Labor	550.00
Telephone calls	50.00
	2,369.37
Total Cost	2,369.37

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for Review January 26, 1973
Reviewed and Revised by Mr. R. Banks, May 10, 1973

RESEARCH PROJECT BRIEF 9-31
Research by Industry

1. Organization Performing Research: Inland Steel.
2. Descriptive Project Title: Test of Miner-Mounted Scrubber with Blowing Face Ventilation
3. Objective of Project: To operate a Joy 10 CM miner fitted with a prototype Gundlach 30 SC scrubber and vary certain ventilation parameters so as to minimize the respirable dust concentration at the operator's station.
4. Summary of Project Progress to Date: It was found that the respirable dust concentration was significantly reduced by reducing the rate of fresh air admission. Compliance with the 2.0 mg/M³ dust concentration was obtained with approximately a 6x rate of recirculation through the scrubber. These experiments have been curtailed by temporary prohibition of the use of a miner-mounted scrubber.
5. Remaining Technological Deficiencies: Extensive investigation of the effects of suction devices located near the cutters will be necessary before scrubbing systems can be properly designed and safely operated.
6. Schedule and Project Funding: This project was suspended and will be continued occasionally for special tests. The direct cost to date is listed below:

ITEM	COST
Nominal cost of prototype scrubber	\$ 2,000.00
Shop installation	422.30
Installing scrubber on miner (twice)	1,372.50
Minor repairs between shifts	598.50
Miscellaneous repair parts	4,000.00
Section down time 25,000 mins.	17,500.00
Miscellaneous idle shift work	915.00
Telephone, pick-up, etc.	500.00
Labor, 1 man full time	<u>11,000.00</u>
Total	38,308.30

A significant additional equipment and engineering cost was borne by Gundlach Machine.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for Review January 26, 1973
Reviewed and Revised by Mr. R. Banks, May 10, 1973

RESEARCH PROJECT BRIEF 9-32
Research by Industry

1. Organization Performing Research: Inland Steel.
2. Descriptive Project Title: Evaluation of Exhaust Tubing
3. Objective of Project: To evaluate the effectiveness of various sizes and makes of flexible and rigid tubing that would allow high rates of air flow to an auxiliary exhaust fan.
4. Summary of Project Progress to Date: The tubing was connected to a 20 hp auxiliary blower and evaluated for air flow, resistance to collapsing, ease of installation under mining conditions. Air flow rates as high as 8,000 cfm were obtained with 250 ft of 20 inch flexible reinforced tubing.
5. Remaining Technological Deficiencies: Exhaust tubing alone has not been approved by the Illinois Mining Board for the Inland mine. The wear properties of the exhaust tubing still have to be evaluated and experiments will have to be conducted to optimize dust suppression with such a system.
6. Schedule and Project Funding: The project will proceed as soon as authorization is obtained from the State of Illinois. The principal direct cost was the purchase of 16 inch PVC tubing for which costs are not available. Other costs of this program were not recorded.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for Review January 26, 1973
Reviewed and Revised by Mr. R. Banks, May 10, 1973

RESEARCH PROJECT BRIEF 9-33
Research by Industry

1. Organization Performing Research: Inland Steel.
2. Descriptive Project Title: Side by Side Testing of MSA Personal Samplers
3. Objective of Project: To evaluate the reproducibility of personal samplers set up side by side to sample a variety of dust concentrations.
4. Summary of Project Progress to Date: MSA undampened personal samplers are being coupled in pairs during the test of the proprietary dust suppressant. One cassette from each pair is evaluated by Inland Steel and the other sent to the U.S. Bureau of Mines for evaluation. To date 54 samples have been evaluated. Significant differences in readings have been noted.
5. Remaining Technological Deficiencies: It is hard to evaluate whether the discrepancies are in the sampling or the handling and weighing.
6. Schedule and Project Funding: The project will continue until at least 100 paired samples have been evaluated. The direct cost of cassettes will be \$250. The cost of the additional pumps, labor, etc. is not included with this program.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for Review January 26, 1973
Reviewed and Revised by Mr. R. Banks, May 10, 1973

RESEARCH PROJECT BRIEF 9-34
Research by Industry

1. Organization Performing Research: Peabody Coal Co. No. 10 Mine.
2. Descriptive Project Title: Test of Sprays and Wetting Agents
3. Objective of Project: The objective of this project was to evaluate sprays for mounting on mining equipment and the use of wetting agent added to the spray water.
4. Summary of Project Progress to Date: Tests were conducted on various types of spray nozzles including Deron nozzles that also require compressed air. Manifold arrangements were designed to supplement the sprays supplied with the mining machinery. Wetting agents were not found effective with this coal. As a result of this project, standardized additional manifolds have been designed for all their continuous miners and conventional mining equipment.
5. Remaining Technological Deficiencies: The personnel at this mine has managed to maintain dust levels close to 2.0 mg/m^3 on their conventional mining sections by the use of sprays and ventilation but they have not been able to reach these levels continuously on the sections that use continuous miners.
6. Schedule and Project Funding: It is felt that the use of available sprays has been optimized and further testing is not planned unless promising new sprays become available. This project was funded by Peabody Coal, but it is corporate policy not to reveal expenditures.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 26, 1973
Reviewed and revised by Mr. R. Whitlow, April 27, 1973

RESEARCH PROJECT BRIEF 9-35
Research by Industry

1. Organization Performing Research: Peabody Coal Co. No. 10 Mine.
2. Descriptive Project Title: Test of Joy Manufacturing Company Miner Mounted Scrubber
3. Objective of Project: To test a factory designed scrubber mounted on a Joy 12 CM miner under mining conditions.
4. Summary of Project Progress to Date: The miner and scrubber were tested briefly prior to the May 1972 cessation of scrubber testing. Further testing is scheduled for February 23, with a special operating permit. Results obtained to date indicated a noticeable reduction in visible dust, less dust in the returns but an undesirable increase in the noise level.
5. Remaining Technological Deficiencies: Considerable testing will be required before a scrubber and its associated ductwork can be considered a satisfactory and acceptable device for a continuous miner.
6. Schedule and Project Funding: Further tests were scheduled for February 1973. The rate of testing will depend upon many undetermined factors, including the special permit to operate. This project was funded by the Peabody Coal Company, but it is corporate policy not to reveal expenditures or estimates.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 26, 1973
Reviewed and revised by Mr. R. Whitlow, April 27, 1973

RESEARCH PROJECT BRIEF 9-36
Research by Industry

1. Organization Performing Research: Peabody Coal Co. No. 10 Mine.
2. Descriptive Project Title: Test of Ledgemont Laboratory Electric Miner Mounted Scrubber
3. Objective of Project: To test a Ledgemont Laboratory scrubber mounted on a Joy 10 CM continuous miner.
4. Summary of Project Progress to Date: The miner and scrubber were tested briefly prior to the May 1972 cessation of scrubber testing. Further testing is scheduled for February 23, with a special operating permit. Results obtained to date indicated a noticeable reduction in visible dust; less dust in the returns but an undesirable increase in the noise level.
5. Remaining Technological Deficiencies: Considerable testing will be required before a scrubber and its associated ductwork can be considered a satisfactory and acceptable device for a continuous miner.
6. Schedule and Project Funding: Further tests were scheduled for February 1973. The rate of testing will depend upon many undetermined factors, including the special permit to operate. This project was funded by the Peabody Coal Co., but it is corporate policy not to reveal expenditures or estimates.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 26, 1973
Reviewed and revised by Mr. R. Whitlow, April 27, 1973

RESEARCH PROJECT BRIEF 9-37
Research by Industry

1. Organization Performing Research: Peabody Coal Co. No. 10 Mine.
2. Descriptive Project Title: Test of Low Cost Foam System
3. Objective of Project: The objective of the program was to adapt the present spraying equipment to operate as a low cost foam generator.
4. Summary of Project Progress to Date: The objective of the project is to determine if reasonable foam generation might be obtained by adding a foam feeder and foam nozzles to the water system used on their conventional mining machines. The prospect appears encouraging enough to warrant a trial installation.
5. Remaining Technological Deficiencies: Foam per se has yet to be established as an effective and suitable means of dust suppression. The spray systems developed for use at this mine have produced promising dust reductions and it is hoped that further improvement will be demonstrated by the use of foam.
6. Schedule and Project Funding: It is expected that the low cost foam system will be assembled and tested in 1973. This project is funded by the Peabody Coal Company, but it is corporate policy not to reveal expenditures.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 26, 1973
Reviewed and revised by Mr. R. Whitlow, April 27, 1973

RESEARCH PROJECT BRIEF 9-38
Research by Industry

1. Organization Performing Research: Peabody Coal Company No. 10 Mine.
2. Descriptive Project Title: Experiments in Water Infusion
3. Objective of Project: The objective of the project was to develop suitable techniques of water infusion to provide a single system for dust control.
4. Summary of Project Progress to Date: Water infusion tubes were obtained from the U.K. Starting with these tubes, equipment was developed to make infusion tests in various sections of the No. 10 mine. It was found that it is hard to predict how well a particular block of coal had been infused. However, with proper infusion, it was found that dust concentration below 2.0 mg/m^3 were readily obtained with conventional mining without the normal water used in any of the operations. From observation of these tests, it has also been concluded that it will take considerable sophistication to develop water infusing equipment that will fit into the present continuous mining cycles.
5. Remaining Technological Deficiencies: It is the judgment of personnel at the No. 10 mine that satisfactory short term water infusion prior to mining should be able to allow essentially dust-free mining without compelling the operator to maintain many minor functions of the equipment in optimum conditions. However, despite these encouraging predictions, water infusion can only be considered an encouraging concept with a technical feasibility that has only been demonstrated in a few successful tests.
6. Schedule and Project Funding: Further infusion tests are planned for 1973. This program was funded by the Peabody Coal Company, but it is corporate policy not to reveal expenditures.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 26, 1973
Reviewed and revised by Mr. R. Whitlow, April 27, 1973

RESEARCH PROJECT BRIEF 9-39
Research by Industry

1. Organization Performing Research: Peabody Coal Company No. 10 Mine.
2. Descriptive Project Title: Survey of Dust Control Technology in the United Kingdom
3. Objective of Project: To gain first hand experience of coal mining developments in the United Kingdom.
4. Summary of Project Progress to Date: Mr. Craggs visited several mines in the Newcastle area, as a guest of the National Coal Board. Mr. Craggs noted that the normal dustiness in the "show" mines was higher than those in many U.S. mines that are presently considered dusty. Mr. Craggs wonders whether the conditions specified as realistic in the "Act of 1969" did not result from an exaggeration of data developed from U.K. sources. Mr. Craggs feels that NCB could profit from an infusion of U.S. technology in most phases of mining, including dust control.
5. Remaining Technological Deficiencies: It would appear that in the past international technology transfer has been somewhat superficial. It is felt, for example, that information on dust measurements, etc., were not backed up with sufficient visits to European mines by U.S. personnel with direct responsibility for health and safety in mines.
6. Schedule and Project Funding: This was a no cost program since Mr. Craggs was on vacation and was a guest of the National Coal Board.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 26, 1973
Reviewed by Mr. R. Whitlow, April 27, 1973

RESEARCH PROJECT BRIEF 9-40
Research by Industry

1. Organization Performing Research: Monterey Coal Company.
2. Descriptive Project Title: Development of Tubing for Exhaust Ventilation
3. Objective of Project: The objective of the project was to develop a system of tubing and auxiliary fans to provide adequate mine ventilation and dust suppression.
4. Summary of Project Progress to Date: Flame proof rigid tubing was made to the Monterey Coal Company's specifications. Trial installations were made with 24, 22, and 20 inch tubing in 20 foot length connected to exhaust fans. It was found that acceptable dust suppression was obtained using 40 hp fans and mostly 24 inch tubing (some 22 inch tubing is telescoped to make end extensible). Despite extra joints 10 foot tubing lengths were found superior. This system of ventilation has been adopted for the whole mine.
5. Remaining Technological Deficiencies: The auxiliary fans are noisy and the dust emitted from the exhaust make frequent rock dusting in the return necessary.
6. Schedule and Project Funding: The use of scrubbers is being considered as a means of cleaning up the exhaust; otherwise, the project is complete. This project was funded by the Monterey Coal Company; cost data is considered proprietary information.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 21, 1973
Reviewed and revised by Mr. P. Lingo, April 6, 1973

RESEARCH PROJECT BRIEF 9-41
Research by Industry

1. Organization Performing Research: Monterey Coal Company.
2. Descriptive Project Title: Test of Sprays, Pumps, Additives
3. Objective of Project: The objective of the project was to evaluate the addition of sprays to continuous mining machines, shuttle car loading points and belt transfers, to evaluate the pumping requirement of continuous miners and to evaluate the use of additives to spray water. All these investigations were aimed at improving dust suppression.
4. Summary of Project Progress to Date: Dust suppression was improved by adding sprays to Jeffrey heliminers, at the shuttle car loading point and at belt transfers. Improved dust suppression was obtained by mounting larger pumps on the continuous miners. Additives were evaluated and Enjay "Dust Suppressant 7-9607" was found effective. All these measure -- use of additional spray, use of larger pump, and use of Enjay additives are used routinely in the mine.
5. Remaining Technological Deficiencies: It appears that the Monterey Coal Company has optimized the use of sprays, pumps, and additives.
6. Schedule and Project Funding: This project is complete. The project was funded by the Monterey Coal Company; cost data is considered proprietary information.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 21, 1973
Reviewed and revised by Mr. P. Lingo, April 6, 1973

RESEARCH PROJECT BRIEF 9-42
Research by Industry

1. Organization Performing Research: Monterey Coal Company.
2. Descriptive Project Title: Test of Scrubber Installed on Jeffrey Heliminer.
3. Objective of Project: The objective of the project was to test a factory installed scrubber on a Jeffrey Heliminer under mining conditions to determine its effectiveness for reducing respirable dust at the operator station and reducing the dust emitted at the exhaust of ventilation fans.
4. Summary of Project Progress to Date: A heliminer with a factory mounted scrubber has been purchased. There are no plans to test this unit until the controversies on scrubber use are resolved.
5. Remaining Technological Deficiencies: The operators feel that the scrubber will improve their operations but do not like the addition of integral equipment or the likely additional noise.
6. Schedule and Project Funding: There are not definite plans to test this scrubber. This program was funded by the Monterey Coal Company; cost data is considered proprietary information.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 21, 1973
Reviewed and revised by Mr. P. Lingo, April 6, 1973

RESEARCH PROJECT BRIEF 9-43
Research by Industry

1. Organization Performing Research: BCR, BCOA, and cooperating coal producers.
2. Descriptive Project Title: BCR-BCOA Underground Respirable Dust Sampling Survey
3. Objective of Project: To obtain dust sampling data using the MRE sampler and several configurations of the Unico and MSA personal samplers for the purpose of:
 1. Checking the operation of the various samplers for consistency in measurement of dust concentrations under identical conditions.
 2. Verifying the correlation between the MRE sampler and the personal samplers.
4. Summary of Project Progress to Date: Made up packages suitable for 1 MRE, 1 Unico undampened, 1 Unico with SKC dampener, 1 MSA undampened, 1 MSA with MSA dampener, 1 MSA with SKC dampener. Seven cooperating companies used packages to test MRE and samplers appropriate to their use. Duplicate sample packages were located in 7 different mines on a continuous miner and in a return. Filters were preweighed and post-weighed by BCR, using the same balance and operators, for 1,200 samples. The results indicated that the samplers tested were not reliable. A publication is pending.
5. Remaining Technological Deficiencies: Statistical analysis has failed to reveal the factors that caused the lack of reliability.
6. Schedule and Project Funding: This program was started April 1972. Final report scheduled for February 1973. The program was funded by BCR for an estimated \$50,000. Estimate does not include costs incurred by BCOA or cooperating coal producers.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 24, 1973
Reviewed and revised by Mr. R. Saltsman, March 15, 1973

RESEARCH PROJECT BRIEF 9-44
Research by Industry

1. Organization Performing Research: Bituminous Coal Research, Inc.
2. Descriptive Project Title: Study of Sprays for Suppression of Airborne Mine Dust
3. Objective of Project: To study the operation of atomizing spray nozzles to determine optimum operating conditions for dust suppression.
4. Summary of Project Progress to Date: Built a test facility with pumping facilities 20-500 psi water pressure, 20-100 psi air pressure. Tested and characterized 200 sprays, recorded data on spray angle, diameter of envelope, effective carry, visible characteristics of the droplet size. Photos were taken of all spray nozzles at lowest, medium, and highest operating pressures. Designed, built, and tested 25 sprays to be used in conjunction with the wet head miner. Did work underground on float dust with Bethlehem mines and Pa. Dept. of Mines, on Deron and John Bean sprays. Spray nozzles tested for effectiveness of knockdown of dust at the face, causing a dust pickup on the miner. Future plans are to simulate mine dust in the BCR dust tunnel to study the knockdown of various sprays chosen from the current correlation study.
5. Remaining Technological Deficiencies: It is difficult to measure droplet size and spray velocity. Despite effort to refine technique such measurements remain either subjective or highly sophisticated. BCR is hoping to resolve these problems by developing simpler measuring techniques.
6. Schedule and Project Funding: The project is a continuing "in-house" program. Expenditures for 1972 were \$13,000, budgeted expenditures for 1973 \$22,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 19, 1973
Reviewed and revised by Mr. R. Saltsman, March 15, 1973

RESEARCH PROJECT BRIEF 9-45
Research by Industry

1. Organization Performing Research: Bituminous Coal Research, Inc.
2. Descriptive Project Title: Construction and Development of Simulated Underground Heading
3. Objective of Project: To build an enclosure in which specific ambient conditions could be established and maintained.
4. Summary of Project Progress to Date: A long isolated steel building has been built, comprising a control room and a dust tunnel section. The control room is 40 feet long, 20 feet wide, and 10 feet high. The tunnel section is 160 feet long, 12 feet wide, and 6 feet high, enclosing an 8 x 6 ft tunnel with a 2 ft return airway on each side. The tunnel is insulated and is supplied with temperature and humidity controlled filtered air. Equipment has been developed to provide a regulated or programmed feed of variously sized dust.

Testing in this facility will be in phases as follows:

 - a. Testing of approved personal samplers and the MRE sampler under controlled, constant environmental conditions to determine operating characteristics.
 - b. Testing of the samplers under simulated mining conditions of varying dust generation as produced by the mining cycle.

Based on the results of these tests, further testing and development work will be planned.

The facility will also be adapted for testing of ventilation, sprays, scrubbers, detectors, noise generation, etc.
5. Remaining Technological Deficiencies: There are no difficulties anticipated with the equipment in the facility. The only difficulty may be in properly analyzing the test data and correlating it to actual mining conditions.
6. Schedule and Project Funding: The dust tunnel was funded by BCR for an estimated \$172,000. The program for 1973 is flexible and will be varied to meet the research needs of the mining industry--test of samplers is scheduled as the first test.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for Review January 19, 1973
Reviewed and revised by Mr. R. Saltsman, March 15, 1973

RESEARCH PROJECT BRIEF 9-46
Research by Industry

1. Organization Performing Research: Bituminous Coal Research, Inc.
2. Descriptive Project Title: Statistical Analysis of Respirable Dust Samplers
3. Objective of Project: To study the performance and reliability of various sampling devices used to measure respirable dust.
4. Summary of Project Progress to Date: Data from the BCR-BCOA study suggest that linear equations do not adequately represent the relationships that exist between the various measurements of respirable dust obtained with different instruments. A statistically designed test program for analyzing the effects of 13 parameters has been formulated. This program could be run "in-house" using the BCR dust tunnel or the program could be used to assist similar research that may be undertaken by others.
5. Remaining Technological Deficiencies: It is hoped that such a study will enable the conflicting data from such sources as Triangle research, BCR-BCOA, U.S. Bureau of Mines (PTS) to be rationalized.
6. Schedule and Project Funding: This program was funded by BCR for approximately \$5,000 in 1972. The program for 1973 is flexible and will be varied to meet the research needs of the mining industry.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 19, 1973
Reviewed and revised by Mr. R. Saltsman, March 15, 1973

RESEARCH PROJECT BRIEF 9-47
Research by Industry

1. Organization Performing Research: Westmoreland Coal Company.
2. Descriptive Project Title: Development of Spray Applications to Minimize Dust Emissions
3. Objective of Project: To study available atomizing sprays and to develop systems for their application to maximize dust suppression without using excessive amounts of water.
4. Summary of Project Progress to Date: The 3/8-inch M-14 sprays by Spraying Systems Inc., have been used for most installations. It was found that optimum dust suppression for a given flow rate required considerable experimentation in the location and orientation of the spray. It was found that water quality had to be carefully maintained and that multiple filtration was necessary to minimize the clogging of sprays. It was found that the best results on mining machines were obtained by installing multiple sprays in box-shaped manifolds at various locations on the machines, including the tail. Similar arrangements were developed for conventional mining sections. Spray locations were determined for belt-loading points and it was found that a spray directed at the underside of the belt reduced significantly the dust emitted from beltways and did not result in slipping problems.
5. Remaining Technological Deficiencies: The Westmoreland Coal Company feels that they have come close to optimizing dust suppression by the diligent application of sprays. Dust concentrations below 2.0 mg/m³ can be maintained at most of their sections. However, the management decided to close down 5 mines, cut back production at 3 mines, and is deciding whether to continue the operation of three more rather than incur the costs required to meet the requirements of the ACT of 1969. Production at the remaining mines is down 40 percent from what it was in 1968. The management does not feel that the use of sprays can be considered adequate technology until it can be proven that they provide satisfactory dust suppression after production is restored to the pre-1968 level. Further loss in productivity is expected with the enforcement of the 2.0 mg/m³ standard.
6. Schedule and Project Funding: This program was funded by the Westmoreland Coal Company. The cost of experimenting with nozzle applications is estimated at \$15,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 31, 1973
Reviewed and revised by Mr. R. Hamrick, March 2, 1973

RESEARCH PROJECT BRIEF 9-48
Research by Industry

1. Organization Performing Research: Westmoreland Coal Company.
2. Descriptive Project Title: Test of Scrubber Mounted on Continuous Miner
3. Objective of Project: To evaluate the effectiveness of a miner-mounted scrubber for suppressing visible and respirable dust.
4. Summary of Project Progress to Date: Tests were begun with a Lee-Norse 455 hard head miner fitted with a fan and duct of Lee-Norse design and a Donaldson scrubbing panel. The initial operation appeared excellent. Further testing prevented by the May 23, 1972 order requiring Bureau of Mines approval of dust collecting system mounted on continuous mining machines.
5. Remaining Technological Deficiencies: This auxiliary ventilation and scrubbing system still has to be evaluated over many working shifts. There is a concern for the additional noise generated.
6. Schedule and Project Funding: The Westmoreland Coal Company plans to resume scrubber testing as soon as it is permitted. The schedule for such testing is uncertain. This program cost \$25,000*; estimated cost of future testing is \$50,000.

* These figures are hard to estimate due to lost tonnage, labor cost and other delays that are difficult to estimate to establish a direct cost.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review January 31, 1973
Reviewed and revised by Mr. R. Hamrick, March 2, 1973

RESEARCH PROJECT BRIEF 9-49
Research by Industry

1. Organization Performing Research: Clinchfield Coal Company.
2. Descriptive Project Title: Experimental Tubing Exhaust System for Conventional Mining
3. Objective of Project: To attempt to develop an effective exhaust system using high power auxiliary fans and large diameter tubing.
4. Summary of Project Progress to Date: 1,400 feet of 36-inch glass reinforced tubing, 1,000 feet of 30-inch tubing and a 100 hp fan were purchased for trial installation at Moss #3 Mine. This system was operated for 4 months without helping the operation to be in compliance with the 3.0 mg/m³ dust limit. No suitable techniques could be developed to store, fit-up, and dismantle the tubing and make it compatible with the mining operation.
5. Remaining Technological Deficiencies: It is doubted that an effective exhaust system using large diameter tubing could ever be developed for in-mine use because of the handling problem and space requirements.
6. Schedule and Project Funding: This program was completed August 1971. This project was funded by the Clinchfield Coal Company for \$20,000 in supplementary labor costs; \$70,000 in equipment costs, excluding the 100 hp fan.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 21, 1973
Reviewed and revised by Mr. R. Ryland April 11, 1973

RESEARCH PROJECT BRIEF 9-50
Research by Industry

1. Organization Performing Research: Clinchfield Coal Company.
2. Descriptive Project Title: Modification of Wilcox Miner to Provide Clean Air for the Jack Setters
3. Objective of Project: To work with the U.S. Bureau of Mines to devise means of reducing the dust produced by a Wilcox miner, especially at the Jack Setters stations.
4. Summary of Project Progress to Date: A Wilcox miner was modified to allow the installation of a duct, two fans, and a scrubber panel. The modification allowed some 5,000 cfm of air to be drawn between the twin augers and exhausted through 10 to 50 ft of 18-inch tubing at the tail of the machine. Recent tests with this modified unit indicate that the revised air flow has improved the environment of the jack setters. Accurate dust measurements are difficult because dust measurements taken by personal samplers are frequently voided in low coal.
5. Remaining Technological Deficiencies: The revised Wilcox miner will have to compete with a new generation of low coal continuous miners which require fewer operators in high risk locations.
6. Schedule and Project Funding: This program was started March 1, 1972, and completion is scheduled July 1, 1973. This program is funded by the U.S. Bureau of Mines for \$115,000 and by Clinchfield Coal Company for \$144,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 21, 1973
Reviewed and revised by Mr. R. Ryland, April 11, 1973

RESEARCH PROJECT BRIEF 9-51
Research by Industry

1. Organization Performing Research: Clinchfield Coal Company.
2. Descriptive Project Title: Experiments in Water Infusion
3. Objective of Project: To test water infusion as a means of dust control.
4. Summary of Project Progress to Date: Infusion tests were made in the Big Tiller, Little Tiller, and Upper Banner seams. There was little success in infusing the coal or reducing the emission of respirable dust.
5. Remaining Technological Deficiencies: It is felt that improved equipment will have to be developed by others before adequate infusion tests can be made. It is also felt that infusion will probably only be successful where there is a minimum of faults.
6. Schedule and Project Funding: This project was completed 1970. The project was funded by the Clinchfield Coal Company for \$10,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 21, 1973
Reviewed and revised by Mr. R. Ryland, April 11, 1973

RESEARCH PROJECT BRIEF 9-52
Research by Industry

1. Organization Performing Research: Clinchfield Coal Company.
2. Descriptive Project Title: Development of Remote Control Equipment
3. Objective of Project: To cooperate with the U.S. Bureau of Mines and the contractor (Bendix) in the expectation of accelerating the use of these new techniques at Clinchfield Coal Company mines.
4. Summary of Project Progress to Date: 1. Experiments will be conducted with a Lee-Norse 245 CM continuous miner equipped with a Bendix remote manual control and a television monitor. 2. Experiments are also being conducted with a shuttle car operated by a soft laser beam. The Clinchfield Coal Company is satisfied that the remote controlled miner can be used to move the operator to a region of improved roof support and of low respirable dust concentrations and that the laser controlled shuttle car can make the present day operation faster and safer. The Clinchfield Coal Company also feels that these developments can lead to automated shuttle car and above ground operation of mining machines--thus reducing the number of persons exposed to the hazards of underground mining.
5. Remaining Technological Deficiencies: The principal deficiencies are those of the Bendix Corporation, the contractor who is developing the remote control equipment.
6. Schedule and Project Funding: The funding of the testing of the remote control equipment will be shared by the U.S. Bureau of Mines and the Clinchfield Coal Company.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 21, 1973
Reviewed and revised by Mr. R. Ryland, April 11, 1973

RESEARCH PROJECT BRIEF 9-53
Research by Industry

1. Organization Performing Research: Island Creek Coal Company,
Island Creek Division.
2. Descriptive Project Title: Improved Sprays on Continuous Mining
Machines
3. Objective of Project: The sources of dust were analyzed. Added sprays
were directed at the bits, at the tail roller, and a spray on the head
was directed at the foot shaft onto the deck of the miner. It was
found that the number of sprays could only be increased to a point
where the fire-clay bottom or floor became adversely affected and be-
came too sloppy for safe and effective operation of mining equipment.
4. Summary of Project Progress to Date: With the maximum use of sprays,
other factors have to be optimized to approach compliance with 2.0 mg/m³
standard.
5. Remaining Technological Deficiencies: Further improvements in spray
applications may be possible, and at this time the Island Creek Coal
Company plans to take advantage of technological advances as they are
made available.
6. Schedule and Project Funding: This project was completed December 31,
1972. The project was funded by Island Creek Coal Company for \$10,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 26, 1973
Reviewed and revised by Mr. C. Linkous, April 4, 1973

RESEARCH PROJECT BRIEF 9-54
Research by Industry

1. Organization Performing Research: Island Creek Coal Company,
Island Creek Division.
2. Descriptive Project Title: Test of Wetting Agent in Spray Water
3. Objective of Project: The objective of the project is to evaluate additives to be routinely added to spray water (1) for ease of application, (2) for improvement in dust suppression by water sprays.
4. Summary of Project Progress to Date: Several types of wetting agents and metering systems were used as well as a solid stick system. The stick system was selected because it can be more readily controlled. A California product of the Firewater Corporation has been used with encouraging results. It was found that "Dowzit" and some other wetting agents would not support combustion and were non-toxic while some would burn and also caused irritation of nose, eyes and ears. Further testing is needed for more conclusive results.
5. Remaining Technological Deficiencies: In some coals wetting agents only produce small improvements in dust suppression and it therefore requires careful testing to demonstrate the merits of any given product. In any particular coal seam the characteristics vary and a wetting agent that has proven highly successful for dust suppression in one coal seam may not produce the desired results with different coal from the same seam or with a different type of coal.
6. Schedule and Project Funding: The initial evaluation was completed December 31, 1972. The extended Firewater test is scheduled for 1973. These programs are funded by the Island Creek Division of Island Creek Coal Company. The initial program cost \$1,500; the estimate for the Firewater program is \$3,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 26, 1973
Reviewed and revised by Mr. C. Linkous, April 4, 1973

RESEARCH PROJECT BRIEF 9-55
Research by Industry

1. Organization Performing Research: Island Creek Coal Company,
Island Creek Division.
2. Descriptive Project Title: Evaluation of Factors Affecting Dust
Generation
3. Objective of Project: The purpose of the project was to attempt to
evaluate the factors of coal type, drainage, and operator technique as
they affect dust production from sections using continuous mining
machines.
4. Summary of Project Progress to Date: It has been concluded that with
the Dorothy, Winifred, No. 5 Block and Alma Seams that inherent dusti-
ness is somewhat lessened by the surface drainage into the seam. Where
these coals are naturally wet they are less dusty, but when they are dry
they are very dusty. The Cedar Grove seams are generally dry and dusty.
It was found that different machine operators often produce varying
amounts of dust, according to their degree of skill.
5. Remaining Technological Deficiencies: None
6. Schedule and Project Funding: This project was completed December 31,
1972. This project was funded by Island Creek Coal Company for \$175,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 26, 1973
Reviewed by Mr. C. Linkous, April 4, 1973

RESEARCH PROJECT BRIEF 9-56
Research by Industry

1. Organization Performing Research: Island Creek Coal Company,
Virginia Division.
2. Descriptive Project Title: Simultaneous Development of Traveling Water
Sprays and Use of Water Infusion for Dust Control
3. Objective of Project: The objective of the project was to develop a
system of moving sprays to apply treated water to a longwall plow and
to develop suitable procedures for infusing a longwall section.
4. Summary of Project Progress to Date: It was found that dust control was
somewhat improved by the use of an especially designed enclosed manifold
equipped with traveling sprays inside the unit and by the application of
short term infusion prior to mining. A suitable system for water
infusion consists of drilling holes, parallel to the face, from the tail
entry 50 and 100 feet from the face. Adequate dust control is obtained
by the combination of infusion, the multiple sprays in the manifold,
and high rates of ventilation. The working conditions were unduly
uncomfortable during this development but the present manifold design
has improved these conditions and has produced acceptable dust levels
in the breathing zone of the employees along the longwall face.
5. Remaining Technological Deficiencies: Despite these improvements, it
is still wet and drafty at the face.
6. Schedule and Project Funding: The desired water infusion techniques
have been reduced to practice. Some of the development was done with
the help of the U.S. Bureau of Mines. The Island Creek contribution to
the development is estimated to be \$400,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Resubmitted for review April 9, 1973
Reviewed by Mr. C. Linkous, April 23, 1973

RESEARCH PROJECT BRIEF 9-57
Research by Industry

1. Organization Performing Research: U. S. Steel Corporation.
2. Descriptive Project Title: Performance of Snubbered and Unsnubbered Samplers
3. Objective of Project: To obtain data for comparison with USEM test results.
4. Summary of Project Progress to Date: Two packages of instruments were used; one was located on continuous mining machine, the other in the return. Each package contained 1 MRE, 3 MSA Model G, and 2 Unico Micronaire units. One MSA and one Unico unit had an SKC snubber, one MSA unit had an MSA snubber, two units had no snubbers. Air samples were taken over 6-7 hours. Number of samples for each set of data were 31-40. The following relationships were found:

$$\frac{\text{MRE}}{\text{MSA}_{(U)}} = 3.1, \frac{\text{MRE}}{\text{MSA}_{(SKC)}} = 2.0, \frac{\text{MRE}}{\text{MSA}_{(MSA)}} = 2.1, \frac{\text{MRE}}{\text{UNICO}_{(SKC)}} = 2.6, \frac{\text{MRE}}{\text{UNICO}} = 3.2$$

Instruments in return indicated lower ratio than those on the continuous miner.
5. Remaining Technological Deficiencies: The ratio listed above are significantly different from those used to interpret compliance with mandatory dust standards.
6. Schedule and Project Funding: Staff time was not available to develop realistic estimates of the cost of this project.

Project Brief prepared by Bituminous Coal Research, Inc.
Prepared by Mr. K. Morse, January 26, 1973

RESEARCH PROJECT BRIEF 9-58
Research by Industry

1. Organization Performing Research: U. S. Steel Corporation.
2. Descriptive Project Title: Accuracy of Manufacturers' Indicated Filter Cassette Weights
3. Objective of Project: To determine accuracy of manufacturer's indicated cassette weights.
4. Summary of Project Progress to Date: Ten Gelman cassettes were weighed by four experienced persons in two different laboratories. One laboratory reported 50 percent exceeded 0.1 mg difference from the manufacturers' weight. The range was 0.0-0.4 mg. The other laboratory reported 30 percent showing more than a \pm 0.1 mg difference and a range of 0.0-0.2 mg. The errors were mostly on the high side thus penalizing the user of the cassette.
5. Remaining Technological Deficiencies: It must be recognized that there are significant inherent inaccuracies in weighing cassettes with tare weights of +4 grams within a required accuracy of .0001 grams. The weighing operations are essentially manual; therefore, there are variations in accuracy between individuals and in the calibration of different balances.
6. Schedule and Project Funding: Staff time was not available to develop realistic estimates of the cost of this project.

Project Brief prepared by Bituminous Coal Research, Inc.
Prepared by Mr. K. Morse, January 26, 1973

RESEARCH PROJECT BRIEF 9-59
Research by Industry

1. Organization Performing Research: U. S. Steel Corporation, Gary Mine.
2. Descriptive Project Title: Cooperative Study with USBM to Determine Instrument Correlations Near Lee-Norse 354 Machine
3. Objective of Project: To determine what relationship existed between MRE and personal sampler, open face filter and midget impingers.
4. Summary of Project Progress to Date: VM-1 filters were used on all gravimetric samplers. Instruments were placed in packages and were located by continuous miner operator, shuttle car operator, roof bolter, and brattice man.

Sampling Rate	Range of Ratios	
	MRE/PS	
2.0 l/min	1.9 - 4.3	} Packages
2.8 l/min	2.5 - 17.5	
5. Remaining Technological Deficiencies: The considerable variance in the ratio of MRE/PS is too great to establish reasonable application of personal sampler as an enforcement tool.
6. Schedule and Project Funding: Staff time was not available to develop realistic estimates of the cost of this project.

Project Brief prepared by Bituminous Coal Research, Inc.
Prepared by Mr. K. Morse, January 26, 1973

RESEARCH PROJECT BRIEF 9-60
Research by Industry

1. Organization Performing Research: U. S. Steel Corporation.
2. Descriptive Project Title: Moisture Effect on Filters
3. Objective of Project: To determine moisture as a cause of weighing error.
4. Summary of Project Progress to Date: Air samples were taken at a working face. Filter weights were checked at various intervals after sampling was complete. Significant weight changes indicated that humidity control was an important consideration in determining weight of respirable dust fraction.
5. Remaining Technological Deficiencies: It must be recognized that proper moisture control is also an important parameter in determining an accurate weight of the dust deposited on a filter.
6. Schedule and Project Funding: Staff time was not available to develop realistic estimates of the cost of this project.

Project Brief prepared by Bituminous Coal Research, Inc.
Prepared by Mr. K. Morse, January 26, 1973

RESEARCH PROJECT BRIEF 9-61
Research by Industry

1. Organization Performing Research: U. S. Steel Corporation.
2. Descriptive Project Title: Filter Tare Weight Variance
3. Objective of Project: To determine variation in weight of filters from different lots.
4. Summary of Project Progress to Date: Fifteen filters were randomly selected from four boxes of MSA filters and two of Gelman. Based upon these 90 filters, the tare weight range was 10.64 mg to 20.77 mg. It is felt that such variance in filter weight would result in variations in flow rate as pumps are set at the same point on flowmeter.
5. Remaining Technological Deficiencies: Variation in filter tare weights raises an important doubt on the quality control practices of the cassette manufacturers.
6. Schedule and Project Funding: Staff time was not available to develop realistic estimates of the cost of this project.

Project Brief prepared by Bituminous Coal Research, Inc.
Prepared by Mr. K. Morse, January 26, 1973

RESEARCH PROJECT BRIEF 9-62
Research by Industry

1. Organization Performing Research: U. S. Steel Corporation.
2. Descriptive Project Title: Comparison of Auxiliary Fan and Tubing with Line Curtain Methods of Face Ventilation with Lee-Norse Miner
3. Objective of Project: Determine effect of water sprays, particle size, distribution velocity at face with tubing at 20 ft and 4 ft.
4. Summary of Project Progress to Date:
 1. CMO exposure well below 20×10^6 MPPCF with both methods of face ventilation.
 2. Water sprays reduced respirable dust by factor of 4.
 3. Dust was settling in returns as far as 1500 ft from discharge of tubing.
 4. Face ventilation with 5000 cfm through tubing and entrance 4-5 from face was optimum dust control. Tubing opening 20 ft from face resulted in poor control.
5. Remaining Technological Deficiencies: Need to develop hood arrangement for end of tubing mounted on miner. Scrubber desirable to minimize spread of dust downstream from the blower exhaust.
6. Schedule and Project Funding: Staff time was not available to develop realistic estimates of the cost of this project.

Project Brief prepared by Bituminous Coal Research, Inc.
Prepared by Mr. K. Morse, January 26, 1973

RESEARCH PROJECT BRIEF 9-63
Research by Industry

1. Organization Performing Research: U. S. Steel Corporation.
2. Descriptive Project Title: Water Applied to Cutting Edges of Lee-Norse Continuous Miner
3. Objective of Project: To determine the effects of water emitted near the cutting edges compared to conventional spray systems.
4. Summary of Project Progress to Date: The equipment was not well enough advanced to allow definite evaluation. The tests were, however, encouraging.
5. Remaining Technological Deficiencies: At the time of the tests the need for improved seals and improved sprays and spray locations was evident.
6. Schedule and Project Funding: Staff time was not available to develop realistic estimates of the cost of this project.

Project Brief prepared by Bituminous Coal Research, Inc.
Prepared by Mr. K. Morse, January 26, 1973

RESEARCH PROJECT BRIEF 9-64
Research by Industry

1. Organization Performing Research: U. S. Steel Corporation.
2. Descriptive Project Title: Dust Suppression with Joy 8CM-Wet Head Continuous Miner
3. Objective of Project: Evaluation of performance wet head machine (80 sprays on discs and 23 conventional) compared to 23 spray machine alone.
4. Summary of Project Progress to Date: Full shift samples obtained with 83 sprays operating over four day period compared to four days with only 23 conventional sprays. Dust samples on CMO, SCO, left side of machine and behind brattice three feet from entrance.
Dust reduction improvement with 83 sprays:
 CMO - 64 percent
 SCO - 17 percent
 Left of CM - 84 percent
 Behind brattice - 79 percent
5. Remaining Technological Deficiencies: Improved water seals to prevent back spray uniform distribution of water.
6. Schedule and Project Funding: Staff time was not available to develop realistic estimates of the cost of this project.

Project Brief prepared by Bituminous Coal Research, Inc.
Prepared by Mr. K. Morse, January 26, 1973

RESEARCH PROJECT BRIEF 9-65
Research by Industry

1. Organization Performing Research: U. S. Steel Corporation.
2. Descriptive Project Title: Dust Suppression with Jeffrey Heliminer Wet Head Continuous Mining Machine
3. Objective of Project: Is to test 1 Jeffrey wet head miner at Gary and 1 at the Concord mine.
4. Summary of Project Progress to Date: These machines have only been briefly tested as wet head miners. Operation to date suggest some improvement in the head seals.
5. Remaining Technological Deficiencies: For effective operation, a commercial wet machine will require either readily serviceable seals or seals that remain leak-proof for 250,000 tons if the head has to be pulled for servicing the seals.
6. Schedule and Project Funding: Staff time was not available to develop realistic estimates of the cost of this project.

Project Brief prepared by Bituminous Coal Research, Inc.
Prepared by Mr. K. Morse, January 26, 1973

RESEARCH PROJECT BRIEF 9-66
Research by Industry

1. Organization Performing Research: U. S. Steel Corporation.
2. Descriptive Project Title: Role of Machine Variables on Dust Concentrations with Boring Machine
3. Objective of Project: To determine variables having major impact upon dust exposure of face operators, such as water rate and pressure, ventilation rate, role of water sprays, and wetting agents.
4. Summary of Project Progress to Date: This was a three year study. The most important variables were found to be:
 1. Ventilation rate.
 2. Water rate through sprays.
 3. Loading rate into shuttle cars.
5. Remaining Technological Deficiencies: There were difficulties in maintaining adequate water pressure, with spray nozzles becoming plugged, with water distribution to the headers.
6. Schedule and Project Funding: Staff time was not available to develop realistic estimates of the cost of this project.

Project Brief prepared by Bituminous Coal Research, Inc.
Prepared by Mr. K. Morse, January 26, 1973

RESEARCH PROJECT BRIEF 9-67
Research by Industry

1. Organization Performing Research: U. S. Steel Corporation.
2. Descriptive Project Title: Investigation of Cryogenic Air Supply
3. Objective of Project: To determine practicability of cryogenic air respirator for CMO.
4. Summary of Project Progress to Date: A practical unit was developed with supplier but more study of economic factors necessary.
The system was well received by the operator who tested it.
5. Remaining Technological Deficiencies: This system has certain inherent disadvantages:
 1. It has to be carried into and out of the mine for each shift.
 2. It is not an approved control measure.
 3. The initial design did not have enough capacity for a complete shift.
 4. It is not portable and tends to restrict mobility of operator.
6. Schedule and Project Funding: Staff time was not available to develop realistic estimates of the cost of this project.

Project Brief prepared by Bituminous Coal Research, Inc.
Prepared by Mr. K. Morse, January 26, 1973

RESEARCH PROJECT BRIEF 9-68
Research by Industry

1. Organization Performing Research: U. S. Steel Corporation.
2. Descriptive Project Title: Analytical Method for Quartz in Respirable Dust
3. Objective of Project: To evaluate accuracy of quartz determinations using sample that is only available in milligram quantities.
4. Summary of Project Progress to Date: The state-of-the-art involves different techniques, none of which is highly accurate. Accuracy increases as amount of total dust increases. Dust must be removed from filter by proper technique deposited upon Belas silver membrane filter along with fixed amounts of an internal standard. X-ray diffraction method is used. The accuracy is \pm 30 percent of the amount of quartz in sample: this accuracy is comparable to other micro-methods.
5. Remaining Technological Deficiencies: None supplied.
6. Schedule and Project Funding: Staff time was not available to develop realistic estimates of the cost of this project.

Project Brief prepared by Bituminous Coal Research, Inc.
Prepared by Mr. K. Morse, January 26, 1973

RESEARCH PROJECT BRIEF 9-69
Research by Industry

1. Organization Performing Research: Bethlehem Mines.
2. Descriptive Project Title: Study of High Pressure Water and Air Atomizing Sprays
3. Objective of Project: To investigate the use of finer droplets to suppress respirable dust at the face.
4. Summary of Project Progress to Date: A satellite high pressure pump and compressed air was piped to 8 DE Ron sprays attached to a continuous miner. There was complete loss of face visibility and little reduction in respirable dust. However, dusty mist droplets were noted being drawn into the inlets of samplers.
5. Remaining Technological Deficiencies: The concept of fine droplet atomization did not appear attractive at the time of the tests but some further development of this concept is probably warranted.
6. Schedule and Project Funding: This project was completed June, 1971. This project was funded by Bethlehem Mines for \$2000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 27, 1973
Reviewed and revised by Mr. T. Crocker, Jr., April 6, 1973

RESEARCH PROJECT BRIEF 9-70
Research by Industry

1. Organization Performing Research: Bethlehem Mines.
2. Descriptive Project Title: Test of Simulated Miner Mounted Scrubber
3. Objective of Project: Was to simulate the effect of a miner mounted scrubber on a Lee Norse continuous mining machine.
4. Summary of Project Progress to Date: A pick-up, electric fan and exhaust duct was built into the machine. The exhaust was connected by flexible tubing to a Donaldson scrubber in the cross cut. Operation was promising during initial tests which were cancelled by the May 1972 order of the U.S. Bureau of Mines.
5. Remaining Technological Deficiencies: It is felt that more detailed ventilation data should be obtained before determining the merits of various proposed systems for operating a miner mounted scrubber.
6. Schedule and Project Funding: Bethlehem Mines plan to resume testing when such tests are permitted. This project was funded by Bethlehem Mines for \$50,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 27, 1973
Reviewed and revised by Mr. T. Crocker, Jr., April 6, 1973

RESEARCH PROJECT BRIEF 9-71
Research by Industry

1. Organization Performing Research: Bethlehem Mines.
2. Descriptive Project Title: Test of Foam for Dust Suppression
3. Objective of Project: Was to conduct full scale tests with a foam generator and nozzles mounted on various mining machines.
4. Summary of Project Progress to Date: A foam generator was mounted on a Jeffrey Coal Mole, on a 30X and on a 26M Lee Norse continuous miner at mines in West and Central Pennsylvania and in East Kentucky. "Chemical Concentrate" and other foams were used. The results indicate dust suppression less effective than with water sprays.
5. Remaining Technological Deficiencies: The factors of cost, lack of face visibility, tend to make foam unattractive regardless of its effectiveness in the suppression of respirable dust.
6. Schedule and Project Funding: This project was completed December, 1972. This project was funded by Bethlehem Mines for \$50,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 27, 1973
Reviewed and revised by Mr. T. Crocker, Jr., April 6, 1973

RESEARCH PROJECT BRIEF 9-72
Research by Industry

1. Organization Performing Research: Bethlehem Steel Corporation.
2. Descriptive Project Title: Long Term Face Operations Improvements
3. Objective of Project: The objective of the project is to develop or improve remote control of mining machines, machine performance, methane control and monitoring, dust control, haulage, illumination, and roof support simultaneously.
4. Summary of Project Progress to Date: Staff studies are being conducted of an extensive program of mining development for possible funding by Bethlehem Steel.
5. Remaining Technological Deficiencies: It is a matter of managerial judgment how far Bethlehem Steel should go it alone in making developments that are probably non-proprietary and will benefit all coal producers.
6. Schedule and Project Funding: The staff study is nearing completion. The study would be funded by Bethlehem Steel.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 27, 1973
Reviewed and revised by Mr. R. Aikman, April 19, 1973

RESEARCH PROJECT BRIEF 9-73
Research by Industry

1. Organization Performing Research: Consolidation Coal Research.
2. Descriptive Project Title: Development of Improved Pick-up for Inlet to Scrubber Duct
3. Objective of Project: To improve efficiency of miner mounted scrubbers by increasing the pick-up of respirable fines near the point of generation.
4. Summary of Project Progress to Date: Consolidation Coal Research did significant preliminary investigation in the laboratory and in the mine on the use of auxiliary fans, tubing, and miner mounted scrubbers. It was concluded that all the components were adequate to develop successful miner mounted scrubbers except the design of a pick-up that would collect a large proportion of the respirable dust released at the face. A program to develop such a pick-up is being considered.
5. Remaining Technological Deficiencies: It will require careful in-mine testing to determine if the Consol concepts of an improved dust pick-up are realistic.
6. Schedule and Project Funding: The testing and development of improved scrubber for integral machine mounting has cost Consolidation Research alone more than \$50,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 27, 1973
Reviewed and revised by telephone by Mr. D. Smith, March 19, 1973

RESEARCH PROJECT BRIEF 9-74
Research by Industry

1. Organization Performing Research: Consolidation Coal, Mountaineer Division.
2. Descriptive Project Title: In-Mine Testing of Strato-Scrubbers Installed on Jeffrey Heliminers
3. Objective of Project: Is to test these scrubbers as the likely principal means of dust control in Mountaineer Division mines.
4. Summary of Project Progress to Date: Four strato-scrubber units have been tested at three mines. The mining conditions are generally 13 ft wide rooms with tubing exhaust ventilation connected to auxiliary fans. Special operating permits were obtained to operate with the scrubber throughput lower than the ventilation rate. Progress at these installations has been investigated by the Mountaineer Division and the Bureau of Mines. The operation of these scrubbers is promising. Publications by the Division and the Bureau are pending.
5. Remaining Technological Deficiencies: Not discussed since the findings will soon be published for the AMC.
6. Schedule and Project Funding: The durability of this scrubber is being tested. No attempt was made to separate the research costs from the normal operating costs.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 27, 1973
Reviewed and revised by Mr. H. Mauck, March 16, 1973

RESEARCH PROJECT BRIEF 9-75
Research by Industry

1. Organization Performing Research: Eastern Associated Coal Corporation.
2. Descriptive Project Title: Calibration and Evaluation of GCA Respirable Dust Monitor
3. Objective of Project: The objective of the project was (1) to determine how well the GCA instrument measured respirable dust compared to the personal sampler, and (2) to evaluate its potential for use in underground coal mining operations.
4. Summary of Project Progress to Date: Laboratory and underground calibration tests have been completed and as a result of these it has been concluded that the GCA unit is a reliable means for measuring respirable dust concentrations. Also, it is considered to be a suitable unit for in-mine diagnosis work where measurements of dust concentrations for a short time period, e.g., 4- minutes, is required.

The GCA unit has recently been used as a research tool on a NIOSH-sponsored project concerned with respiratory protective devices for coal miners.
5. Remaining Technological Deficiencies: See 7-13, "Coal Mine Dust Instantaneous Dust Monitor," for latest developments funded by NIOSH.
6. Schedule and Project Funding: The work under this particular project is essentially complete. The project was funded by Eastern for \$15,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 28, 1973
Reviewed and rewritten by Mr. H. Harris, May 9, 1973

RESEARCH PROJECT BRIEF 9-76
Research by Industry

1. Organization Performing Research: Eastern Associated Coal Corporation.
2. Descriptive Project Title: Test of Improved Filtering Techniques for Spray Lines
3. Objective of Project: The objective of the project was to devise improved techniques for filtering the particulates that tend to clog spray nozzles.
4. Summary of Project Progress to Date: In line filters of the Cuno type were tested. These filters can be cleared a few times by rotating a handle on top, but a 30-minute dismantling and cleaning procedure is eventually required. Y-type line strainers were also tried with different screen sizes. These filters clog fairly rapidly but can be rapidly cleaned. The Y filters were found to be the most satisfactory protection against the clogging of sprays, although Cuno filters were sometimes installed downstream for final filtration.
5. Remaining Technological Deficiencies: The provision of clean spray water is important for the proper operation of sprays. It is also a continuing managerial problem to persuade operating personnel to keep the sprays clear.
6. Schedule and Project Funding: The project is complete. This project was funded by Eastern Associated Coal Corporation. Cost data not available.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 28, 1973
Reviewed and revised by Mr. W. Laird, May 4, 1973

RESEARCH PROJECT BRIEF 9-77
Research by Industry

1. Organization Performing Research: Eastern Associated Coal Corporation.
2. Descriptive Project Title: Test of Jeffrey Scrubber with Donaldson Panel
3. Objective of Project: The objective of the project was the sustained testing of the scrubber to determine if the components would stand up under mining conditions.
4. Summary of Project Progress to Date: The test installation has been operated at the Laurel Mine. It was decided that the scrubber was a significant improvement to a continuous mining machine. Some wear was noted on the static blades of the scrubber. Other materials, such as a rubber coating, are being evaluated as means of extending blade life.
5. Remaining Technological Deficiencies: This is one of the few long term scrubber tests. The results indicate that durable second generation units can be expected. Scrubbers in themselves are not necessarily the solution to dust control at each mine. The inherent dustiness of the coal has to be evaluated as well as the cutting techniques that are most suitable to mine that coal with minimum dust release.
6. Schedule and Project Funding: It is expected that this project will be continued indefinitely to accumulate operating data on this scrubber. Cost data not available.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 28, 1973
Reviewed and revised by Mr. W. Laird, May 4, 1973

RESEARCH PROJECT BRIEF 9-78
Research by Industry

1. Organization Performing Research: Eastern Associated Coal Corporation.
2. Descriptive Project Title: Test of Water Infusion for Dust Suppression
3. Objective of Project: The objective of the project was to assist the U.S. Bureau of Mines in the conducting of experiments with water infusion to reduce dust and methane emissions.
4. Summary of Project Progress to Date: Labor, power, ventilated mine space, etc. was made available for the conduct by the U.S. Bureau of Mines of water infusion tests.
5. Remaining Technological Deficiencies: Not applicable.
6. Schedule and Project Funding: The tests have been completed. The assistance rendered was funded by Eastern Associated Coal Corporation but the main concern was not the cost but the chance to help in a venture that might improve the health and safety of the miners.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 28, 1973
Reviewed and revised by Mr. W. Laird, May 4, 1973

RESEARCH PROJECT BRIEF 9-79
Research by Industry

1. Organization Performing Research: Eastern Associated Coal Corporation.
2. Descriptive Project Title: Test of Ingersoll-Rand modified Lee Norse Miner
3. Objective of Project: The objective of the project will be to assist the contractor in the conduct of the necessary tests.
4. Summary of Project Progress to Date: The Eastern Associated Coal Corporation will be reimbursed for making available on demand four miners to help in the initial underground testing. Power, haulage, roof support, ventilation, and coal removal will be supplied as necessary without reimbursement.
5. Remaining Technological Deficiencies: Not applicable.
6. Schedule and Project Funding: The non-reimbursed items will be funded by the Eastern Associated Coal Corporation. No estimates of the non-reimbursable costs have been made.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 28, 1973
Reviewed and revised by Mr. W. Laird, May 4, 1973

RESEARCH PROJECT BRIEF 9-80
Research by Industry

1. Organization Performing Research: Eastern Associated Coal Corporation.
2. Descriptive Project Title: Test of Lee Norse Wet-head Continuous Mining Machine
3. Objective of Project: The objective of the project was to operate the wet-head miner to determine if it enabled better dust suppression than a comparable unit equipped with sprays.
4. Summary of Project Progress to Date: The Lee Norse wet-head miner was operated briefly, but the operators were not successful in maintaining pressure in the head long enough to evaluate its effectiveness for dust suppression. The normal sprays were therefore installed on this machine which has since been used in the conventional way.
5. Remaining Technological Deficiencies: A machine of this type needs to be operated long enough for the wet-head concept to be evaluated.
6. Schedule and Project Funding: No further wet-head tests are planned with this machine. This project was funded by Eastern Associated Coal Corporation, but no cost estimate is available.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 28, 1973
Reviewed and revised by Mr. W. Laird, May 4, 1973

RESEARCH PROJECT BRIEF 9-81
Research by Industry

1. Organization Performing Research: Jeffrey Mining Machinery Company.
2. Descriptive Project Title: Development of an Integral Dust Collector for Mounting on a 120 H, M, or L Heliminer
3. Objective of Project: The objective of the project was to develop a heliminer mounted dust collector to remove visible and respirable dust.
4. Summary of Progress to Date: A unit has been developed that includes a fan mounted on the front of the miner with a central bottom inlet. Air is drawn from the face, through inertial vortex dust separators and discharged from a left or right opening towards the rear of the machine. This unit is available for sale, but special permits are presently required for their operation. Approximately twenty-five units have been sold.
5. Remaining Technological Deficiencies: The Jeffrey Mining Machinery Co. feels that the integral dust collector is their most effective development for dust suppression and are confident that the current problem of integrating the machine mounted fan with the mine ventilation system will soon be adequately resolved.
6. Schedule and Project Funding: The Jeffrey Mining Machinery Company plans to continue dust collector development to resolve the problem of integrating of the dust collector with the mine ventilating system. This project has been funded by Jeffrey for approximately \$96,000 as of December 31, 1972.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 20, 1973
Reviewed and revised by Mr. R. Agin, February 23, 1973

RESEARCH PROJECT BRIEF 9-82
Research by Industry

1. Organization Performing Research: Jeffrey Mining Machinery Company.
2. Descriptive Project Title: Development of Systems for Machine Mounting Foam Generation Equipment
3. Objective of Project: The object of the project was to work with MSA Research to develop practical means of dispersing foam from continuous and auger head mining machines.
4. Summary of Project Progress to Date: Mountings were developed as necessary to mount foam generating and spraying equipment on all Jeffrey machines used in various MSAR foam studies. The development of an adjustable foam sprayer for the 100 L auger head machine required considerable development.
5. Remaining Technological Deficiencies: Foam appears to be inherently expensive for dust control, but it is felt that it should not be ruled out especially for low coal units and obsolescent equipment.
6. Schedule and Project Funding: There are no current plans to work with foam equipment, but the Jeffrey Mining Machinery Company will cooperate with further foam development when requested. This project has been funded by Jeffrey for approximately \$3,000 as of December 31, 1972 in excess of reimbursement under various contracts.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 20, 1973
Reviewed and revised by Mr. R. Agin, February 23, 1973

RESEARCH PROJECT BRIEF 9-83
Research by Industry

1. Organization Performing Research: Jeffrey Mining Machinery Company.
2. Descriptive Project Title: Dust Suppression by Water at the Cutting Element of 100 L Auger Miner
3. Objective of Project: To develop seals and nozzle arrangement to apply water to the augers of a 100 L miner.
4. Summary of Project Progress to Date: A seal suitable for mounting at the drive end of the auger has been developed and shop tested. The most practical location of sprays can only be made after field testing, but nozzles located on the shaft of the auger adjacent to each bit appears to be promising. A few such machines will be made available to selected customers.
5. Remaining Technological Deficiencies: Dust control in low coal miners is inherently difficult. There are three workers in high risk dust areas: 1 operator and 2 jack setters, and no one to date appears to have discovered how to lower the dust levels at these stations adequately. Wet head operation appears to be a promising development.
6. Schedule and Project Funding: This project will continue in 1973. Funded as of December 31, 1972 by Jeffrey of approximately \$45,000 to date.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 20, 1973
Reviewed and revised by Mr. R. Agin, February 23, 1973

RESEARCH PROJECT BRIEF 9-84
Research by Industry

1. Organization Performing Research: Jeffrey Mining Machinery Company.
2. Descriptive Project Title: Dust Suppression by Water at the Cutting Element for the 120 H, M, and L Heliminer
3. Objective of Project: To develop feeding system, seals and nozzle arrangement to apply water to the auger of the 120 H, M, and L heliminer.
4. Summary of Project Progress to Date: It has been found that satellite carts housing the necessary pumps, filters and receivers are superior to machine mounted equipment. Seal development has proceeded to where a promising wide diameter seal can be made available to selected customers who wish to experiment with such equipment. Suitable spray locations have been selected that provide a separate spray for each bit. Prototype units have been purchased by U.S. Steel for use at the Gary and Concord mines.
5. Remaining Technological Deficiencies: The Jeffrey Mining Machinery Company feels that wet head operation will enable dust suppression comparable to that obtained with their integral dust collector, but they feel that the wet head has the following disadvantages:
 - (1) A durable unit still has to be reduced to practice.
 - (2) The first cost of a wet head unit will probably be higher than a unit with an integral dust collector.
 - (3) The cost of maintaining a wet head unit will probably be higher than maintaining a dust collector unit.
6. Schedule and Project Funding: The development of wet head technology using Jeffrey funds will continue in 1973. This project has been funded by Jeffrey for approximately \$84,000 as of December 31, 1972.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 20, 1973
Reviewed and revised by Mr. R. Agin, February 23, 1973

RESEARCH PROJECT BRIEF 9-85
Research by Industry

1. Organization Performing Research: MSA Research.
2. Descriptive Project Title: The Development of High Expansion Foam Systems for the Suppression of Respirable Dust
3. Objective of Project: Was to supplement the work funded by the Commonwealth of Pennsylvania and NIOSH and to assist coal producers who wished to conduct their own experiments.
4. Summary of Project Progress to Date: MSA Research has helped with foam experiments by R & F Coal Company, Kaiser Steel and Island Creek Coal Company. MSA Research has worked extensively with Jeffrey Mining Machinery Company on the development of miner mounted foam packages.
5. Remaining Technological Deficiencies: Many foam developments have been hindered by attempts to use foam where mining conditions are unduly difficult. The personnel at MSA Research feel that foam can be developed as an effective tool for dust suppression.
6. Schedule and Project Funding: It is expected that there will be a continuing corporate effort of development and technical assistance. Since 1969 MSA Research has funded the project for \$40,000 in excess of funding by the Commonwealth of Pennsylvania and NIOSH.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 23, 1973
Reviewed and revised by Mr. R. Hiltz

RESEARCH PROJECT BRIEF 9-86
Research by Industry

1. Organization Performing Research: North American Coal Corporation, Central Division.
2. Descriptive Project Title: Test of Sprays, Pumps, Additives
3. Objective of Project: Was to evaluate additional sprays, and the necessary additional pumping equipment.
4. Summary of Project Progress to Date: It was found that higher pressures and volumes were required to produce the desired spray patterns. Satellite pumps were found superior to mounting auxiliary pumps on the miner. Additives were not found effective. The Central Division is using a system of additional sprays which it developed itself and satellite pump developed in cooperation with a manufacturer.
5. Remaining Technological Deficiencies: Compliance with the current 2.0 mg/m³ is rarely obtained using sprays and optimized ventilation.
6. Schedule and Project Funding: This project is complete. The project was funded by North American Coal Corporation for \$36,000.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 28, 1973
Reviewed and revised by Mr. W. Goddard, March 6, 1973

RESEARCH PROJECT BRIEF 9-87
Research by Industry

1. Organization Performing Research: North American Coal Corporation, Central Division.
2. Descriptive Project Title: Test of Jeffrey Strato Scrubber
3. Objective of Project: Was the in-mine testing of a Strato scrubber built into a Jeffrey heliminer.
4. Summary of Project Progress to Date: Initial tests were undertaken. There were mechanical problems with the scrubber, but its operation was generally promising. Scrubber tests were suspended in May, 1972.
5. Remaining Technological Deficiencies: The operators feel that a system which either prevents the production of respirable dust or its release into the air could be superior to a scrubber. However, since this presently is impossible to accomplish, the development of a scrubber and its acceptance by the BOM is imperative. The bugaboos on recirculation must be laid to rest by research in this area. Our best hopes for compliance with the respirable and float dust standards are to allay these dusts near their source by the use of scrubbers or other similar methods.
6. Schedule and Project Funding: The North American Coal Corporation plans to restore and test the Strato scrubber when such tests are permitted by the BOM. Testing costs to date have been borne by the Jeffrey Manufacturing Company.

Project Brief prepared by Bituminous Coal Research, Inc.
Submitted for review February 28, 1973
Reviewed and revised by Mr. W. Goddard, March 6, 1973

RESEARCH PROJECT BRIEF 9-88
Research by Industry

1. Organization Performing Research: Old Ben Coal Corporation.
2. Descriptive Project Title: Test with Exhaust Fan Mounted on Goodman Miner
3. Objective of Project: To see if a fan mounted on a miner in conjunction with blower type tubing could be used as an exhaust system for dust removal.
4. Summary of Project Progress to Date: The fan was mounted on a miner along with associated ductwork. The unit was operated for a few shifts but due to the limited space for fan clearance on the miner, the fan was damaged by the passage of coal up the conveyor throat. The unit was removed. Further review is expected of this project.
5. Remaining Technological Deficiencies: With smaller size fans capable of handling four to five thousand cfm with 120 ft of blower tubing this project could have some advantages over exhaust systems using exhaust type tubing for boring type miners.
6. Schedule and Project Funding: The project cost \$5,000.

Project Brief prepared by Mr. P. Bailie, April 17, 1973

RESEARCH PROJECT BRIEF 9-89
Research by Industry

1. Organization Performing Research: Old Ben Coal Corporation.
2. Descriptive Project Title: Test of Original Gundlach Scrubber for Ripper Type Continuous Miner
3. Objective of Project: To determine if a scrubber could be used for dust collection on a ripper miner.
4. Summary of Project Progress to Date: This unit was tested off and on for about one year beginning in December 1970. This was some of the earliest test work done on the Gundlach prototype. Many modifications were made in the speed, intake, and outlet locations. Considerable improvement in dust at the face was noted; however, the unit did not have adequate cfm capacity to handle the ripper dust loadings.
5. Remaining Technological Deficiencies: Higher capacity scrubbers were required and presently are available on the market.
6. Schedule and Project Funding: The project cost \$10,000.

Project Brief prepared by Mr. P. Bailie, April 17, 1973

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