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Coal Mine Health Seminar

A Joint Staff Conference of the Bureau of Mines and the National Institute for Occupational Safety and Health

Compiled by Marilyn K. Hutchison, M.D.

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COAL MINE HEALTH SEMINAR

A Joint Staff Conference of the Bureau of Mines and the National Institute for Occupational Safety and Health

compiled by

Marilyn K. Hutchison, M.D.[1]

ABSTRACT

Senior staff representatives of the Bureau of Mines and the National Institute for Occupational Safety and Health (NIOSH) met in Washington on September 6, 1972, to review and evaluate their cooperative accomplishments to date and to consider the planning and conduct of future coordinated activities. The six presentations given at this joint staff seminar are published here for the benefit of those concerned with the problems of coal mine health, and especially those with responsibilities in administering the Coal Mine Health and Safety Act of 1969.

INTRODUCTION

Title II of the Federal Coal Mine Health and Safety Act of 1969 (Public Law 91-173) authorized mandatory health standards to be established and enforced in all underground coal mines to protect the health of coal workers. The establishment of health standards has been a function of the National Institute for Occupational Safety and Health (NIOSH), acting for the Secretary of Health, Education, and Welfare; enforcement has been carried out by the Bureau of Mines, acting for the Secretary of the Interior.

Since enactment of the law, substantial progress has been achieved in making the underground environment in coal mines more healthful and in improving the personal health of the miners. The average levels of respirable dust in underground mines have been cut in half, and the first industry-wide medical survey to detect the presence and extent of coal workers' pneumoconiosis has been completed.

These advances stemming from the operating programs of the Bureau of Mines and NIOSH have required close interaction and cooperation between the two agencies. This seminar was arranged to assure continued progress in implementing the health provisions of the law.

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[1] Liaison officer, National Institute for Occupational Safety and Health to the Bureau of Mines.

WELCOME

by

Donald P. Schlick[1]

We are here to discuss the problems, progress, and future plans of the health provisions of the Coal Mine Health and Safety Act of 1969. Since these provisions started going into effect in mid-1970, a lot has happened. A lot has been accomplished.

The respirable dust provisions for underground coal mining went into effect in mid-1970. There were many problems in the beginning--problems in educating the operators and ourselves to use new and unfamiliar equipment and techniques to sample for respirable dust, and problems in just getting the equipment in the very beginning.

We in the Bureau of Mines had hundreds of individual little problems with hundreds of individual little answers. For instance, we had to arrange for a special, early delivery of mail so that respirable dust samples could be processed on the same day as they were received in our laboratory in Pittsburgh. We had to arrange for the voltage to be regulated in an old Bureau building, so that the data from the samples could be key-taped correctly.

We learned the law of perversity of matter: if something could go wrong, it would go wrong. We learned to crawl, to walk, and then to run. We have stumbled a lot, but today the Bureau administers the most extensive respirable dust monitoring program in the world. We have been successful. Those who challenged our early efforts have been proven wrong. By we, I mean not only the Bureau but the entire mining community--the industry, the miners, and the operators. The operators on whom rests the onus of improving working conditions will profit by having a more healthy, stable, and productive work force. The miners will profit because the sole purpose of the Coal Mine Health and Safety Act is their betterment. The Bureau of Mines and NIOSH will profit because it is our purpose to administer and enforce the Act.

Again, it is the purpose of this meeting to discuss our problems, progress, and plans.

The emphasis is on progress. If this meeting was held last year, it might have been too early to have reported much progress. If it were to be held next year, it may have been too late to plan for the future effectively.

Now, some of the results are in. We know that respirable dust exposures are lower. And, we believe that exposures can be reduced to comply with the new, lower limits which go into effect December 30, 1972. We know that progress has been made with all the other health provisions of the Act and that, ultimately, we the mining community will safeguard the well-being of the miners.

[1]Deputy director, Health and Safety, Bureau of Mines, Department of the Interior, Washington, D.C.

INTRODUCTORY REMARKS

by

Raymond T. Moore, M.D.[1]

I think that today it is appropriate to review our activities in relation to the Federal Coal Mine Health and Safety Act of 1969, Public Law 91-173. The Act provided authority for the Department of Health, Education, and Welfare (HEW) to undertake an expanded program to provide health protection for the active coal miner. I will not try to describe or discuss all of our activities. Drs. Morgan and Gelderman, and Messrs. Shoub and Lynch will address themselves to specific areas later in the program. However, I will list one of them.

The Act confers upon HEW the primary responsibility for some 27 actions. In 11 of these areas, this responsibility is either shared by the Bureau of Mines, or the Bureau has related responsibility under the same authority. Of necessity, a strong association has developed between our two agencies. This association has been facilitated by the assignment of a full-time liaison officer from NIOSH to the Bureau.

I believe that the first reference to cooperation between the Bureau of Mines and the Public Health Service (PHS) was in 1910, when the Surgeon General assigned PHS personnel to accompany Bureau personnel while mine visits were being made in the coal-producing areas. As I reviewed the documents, it seemed to me that the greatest problem at that time was providing lodging and subsistence in the special railway cars used by the Bureau of Mines. Through the years there has been a high level of cooperation between our respective agencies. These cooperative activities included the Tri-State Survey of lead and zinc mines in Kansas, Oklahoma, and Missouri before World War I, and a later survey study of the same area in the 1930's, as well as the Silicosis Survey of Western Metal Mines in 1958-60. These studies were directed to the control or a better understanding of silicosis, and helped immeasurably in the assay of dust exposure and in defining the role of such factors as particle size, composition of the dust, and duration of exposure. The year 1935, or thereabouts, saw the recognition of five cardinal factors in the etiology of dust diseases of the lung. These are composition of the dust, concentration of the dust, size of the dust particle, duration of exposure, and individual susceptibility.

One example of HEW responsibility is the Service X-Ray Study. Title II of the Federal Coal Mine Health and Safety Act directed the "operator of a coal mine to cooperate with HEW in making available to each miner working in a coal mine, the opportunity to have a chest roentgenogram within 18 months after the date of enactment of this Act; a second chest roentgenogram within

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3 years thereafter; and subsequent chest roentgenograms at such intervals thereafter--not to exceed 5 years--as the Secretary of HEW prescribes." Attention also was given to X-rays of new miners. HEW was made responsible for prescribing the regulations under which these examinations would be made.

At this time, something over 73,000 films have been received in Morgantown, W. Va., representing perhaps 69,000 miners. We are not certain of the percentage of eligible miners that have been examined since the figures we have received for the universe of eligible miners is at variance. Mr. Shoub will present current data later in the day.

As we have gained experience with this program, it has become all too clear that the disease, coal workers' pneumoconiosis, is not well understood, nor is there skill in the usage of the classification scheme.

The engineering aspects of our program are managed and directed by Mr. Jeremiah Lynch, Director of the Division of Laboratory and Criteria Development, in Cincinnati, Ohio. Mr. Lynch appears on the program this afternoon.

Last November, we dedicated a new facility on the campus of the West Virginia University Medical Center. The building was designed to house some 200 people and was the culmination of several years of activity on the part of many people in both the executive and legislative branches. The Appalachian Laboratory for Occupational Respiratory Diseases (ALFORD), as well as the Testing and Certification Branch Laboratory, are housed here. The building is attractive and comfortable, and I am sure will enhance our work at Morgantown.

We are pleased to have this opportunity to discuss with our counterparts in the Bureau of Mines some of our accomplishments as well as problems as we seek to fulfill our mission under the Federal Coal Mine Health and Safety Act.

RESPIRABLE DUST IN THE MINE ENVIRONMENT

by

Murray Jacobson[1]

INTRODUCTION

The mandatory health standards of the Federal Coal Mine Health and Safety Act of 1969 pertaining to respirable dust have been in effect since June 30, 1970. The provisions established strict repirable dust standards for the coal mining industry for the first time in its history. The effort leading up to the establishment and enforcement of the standards and some of the findings at the end of the first and second years are presented.

The environmental dust survey was initiated early in 1968, and 29 underground coal mines were evaluated by early 1969. The mines selected fulfilled the following criteria:

1. The bituminous coal mines selected had a minimum operational expectance of 10 years and employed at least 20 men underground.

2. Ten consecutive days were required to be spent at each mine to obtain statistically valid data.

3. The mines selected had productivities ranging from less than 5 to greater than 50 tons per man shift.

4. The mines selected had seam thicknesses from less than 30 inches to greater than 121 inches and covered 19 different coal seams.

5. The types of sections sampled were continuous, conventional, a combination of continuous and conventional, and handloading. The selection of the sections to be sampled in the mines was dependent on the number and types of sections in the mine, and the results were used in determining the average exposure of the miners employed in specific operations over the entire work shift.

6. The number of mines selected in each of the Coal Mine Health and Safety Districts in the continental United States was based on the percentage of underground bituminous mines in the respective districts.

Each miner on the selected section crew was equipped with a personal gravimetric sampler operated for the entire shift. In addition, three sampling packages, each containing personal, MRE, total airborne, and midget impinger samplers, were employed on each section. One package was placed on or near the coal-cutting equipment adjacent to the operator; the second

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package was in the immediate vicinity of the workers who were indirectly involved with the coal-cutting operation, primarily the roof bolters; and the third package was placed in the intake air entry to the section. These samplers operated the entire time the working crew was on the section.

Data obtained were used to determine the occupations exposed to the highest concentrations of respirable dust in the face areas of the mines. In addition, a linear relationship was derived between data collected with the personal samplers and with the MRE. The average ratio of individual MRE to personal sampler data is approximately 1.6. The importance of this relationship must be emphasized. The regulations of the Federal Coal Mine Health and Safety Act of 1969 state that respirable coal mine dust samples are to be collected with the MRE or any other equivalent device approved by the Secretary of the Interior and the Secretary of Health, Education, and Welfare. The empirical relationship of 1.6 permits the use of the personal sampler and the reporting of data in terms of equivalent MRE concentrations.

FEDERAL COAL MINE HEALTH AND SAFETY ACT

Requirements

The Federal Coal Mine Health and Safety Act of 1969 provides for the protection of the health and safety of persons working in the coal-mining industry of the United States. It is also known as Public Law 91-173.

As specified in Section 203(a), Title II of the Act, each operator of a coal mine shall take accurate samples of the amount of respirable dust in the mine atmosphere. Beginning June 30, 1970, the operator of each coal mine was required to maintain the average concentration of respirable coal mine dust at or below 3.0 milligrams of dust per cubic meter of air. The standard is to be reduced to 2.0 milligrams per cubic meter after December 30, 1972.

The Act requires frequent sampling by the mine operator in accordance with the regulations prescribed by the Secretary of the Interior and the Secretary of Health, Education, and Welfare. Every coal mine operator is required to take monthly samples of the "high-risk" occupation in each coal-producing section. The high-risk occupation is one in which, as indicated by previous information, the worker is exposed to the highest concentration of respirable dust. Therefore, if the high-risk occupation is in compliance with the dust standard, then all other occupations in the area are assumed to be in compliance.

In addition to those "high-risk" samples required in coal-producing sections, a sample of the intake air is required monthly, and all underground workers must be sampled periodically. All samples are taken portal-to-portal, and the respirable dust concentrations are computed based on the worker's total time underground.

Processing

All samples collected by the mine operators are analyzed at the controlled environment laboratory of the Bureau of Mines in Pittsburgh, Pa. The laboratory and procedures followed in processing respirable dust samples are described in Bureau of Mines Information Circular 8520, Respirable Mine Dust Sample Processing Laboratory.

A flow diagram of the mine dust monitoring system is shown in figure 1. As of June 30, 1972, a total of 673,468 samples have been processed in the laboratory, which equates to approximately 30,000 samples per month, or 1,600 per day. The laboratory has a planned peak capacity of about 3,000 to 3,500 samples per day; however, since the health standards for surface operations became effective, peak loads of 50,000 plus and daily inputs of over 3,500 were encountered. Upon completion of the analysis, the information is transmitted to the Bureau of Mines automatic data processing center in Denver, Colo., where dust concentrations are determined and stored for calculation and comparison against existing dust standards. This facility is linked with the various Coal Mine Health and Safety District and Subdistrict Offices to provide reliable and rapid printouts of respirable dust data within hours after receipt of the sample in Pittsburgh.

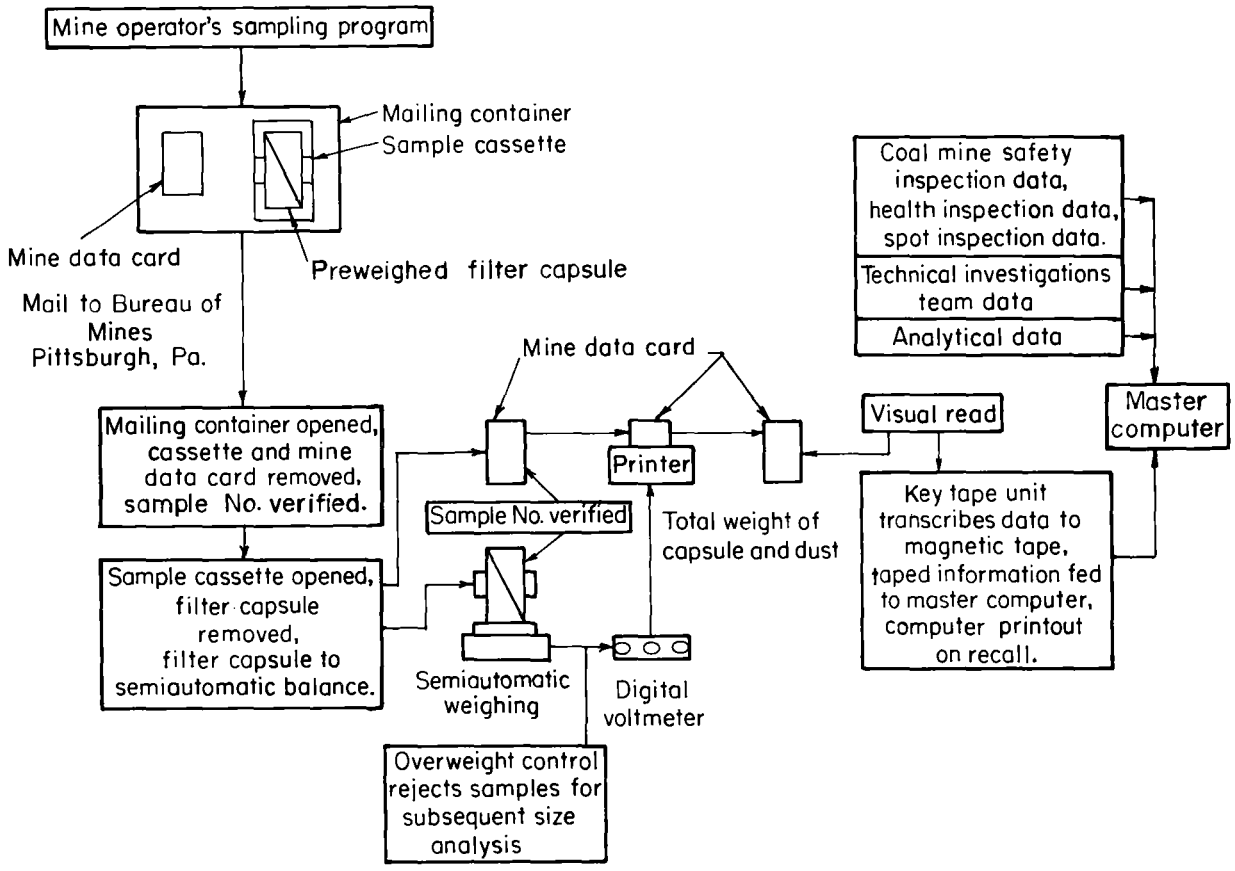

FIGURE 1. - Mine Dust Monitoring System.

RESULTS

To study the effect of the mandatory dust program on the reduction of the respirable dust exposure of the miners, a comparative evaluation of dustiness for high-risk occupations by sections in the 29 previously surveyed mines was conducted. In the 1968-69 survey, 155 sections were sampled. The data are reported as the cumulative percent of the sections whose MRE equivalent dust concentrations fall in the following categories: equal to or less than 1.0 mg/m^3; 2.0 mg/m^3; 3.0 mg/m^3; and 4.5 mg/m^3. These data appear in table 1.

TABLE 1. - Comparison between mean dust concentration of "high-risk" samples, original 29 mines versus all mines

Respirable dust	<1 mg/m^3	<2 mg/m^3	<3 mg/m^3	<4.5 mg/m^3
Survey data 1968-69, 155 sections.....	6.5	20.6	28.4	49.0
Sampling program 1970-71, 288 sections..	13.2	35.4	59.4	84.7
Sampling program 1971-72, 305 sections..	14.8	49.8	74.1	94.1
Sampling program, June 1971.....	21.3	63.2	88.9	99.9
Sampling program, June 1972.....	33.0	76.9	94.9	99.9

Data obtained from the coal mine operators' sampling program of the Federal Coal Mine Health and Safety Act of 1969 are similarly presented for the period of July 1, 1971, to June 30, 1972, for these 29 selected mines. These results represent the average of total data available for the sections in the 29 mines, and not the average of 10 samples. It must be remembered that specific section comparisons cannot be determined owing to the relatively short life of a coal mine working section.

Comparing the data, it is evident that the percentage of sections complying with a 3.0 mg/m^3 standard is approximately three times what it was prior to the law--74 percent as opposed to 28 percent. Increases are likewise evident for the other concentration levels. It further shows that about 50 percent of the sections in these 29 mines will now meet a 2.0 mg/m^3 standard limit.

It is also shown that the distribution of respirable dust concentrations for high-risk occupations for all mine sections, from which data was available at the end of the first and second years of the Federal Coal Mine Health and Safety Act of 1969, is considerably higher than results obtained from the original survey in the 29 mines. These data are for active mine sections which had a complete sampling cycle as of June 30, 1972. They indicate that approximately 95 percent of these sections were in compliance with the 3.0 mg/m^3 standard, and 77 percent were at or below a level of 2.0 mg/m^3.

A further comparative evaluation of the dust concentrations was performed for certain occupations where comparative data were present between original survey data and data obtained under the Act. These data are shown in table 2.

TABLE 2. - Comparison of mean dust exposures, selected occupations

Occupation	Survey data 1968-69, 29 mines	Dust program July 1970 to June 1971, 29 mines	Dust program July 1971 to June 1972, 29 mines	Dust program July 1971 to June 1972, all mines
Continuous miner operator..	6.5	3.1	2.6	2.1
Loading machine operator...	6.0	2.7	2.2	1.7
Cutting machine operator...	5.9	2.9	2.2	1.7
Shuttle car operator.....	2.3	1.6	1.5	1.4
Laborer.....	10.4	2.9	1.2	1.7
Timberman.....	3.9	1.7	1.7	2.2
Roof bolter.....	3.9	2.3	1.9	2.1

Of the original 21 occupations studied, eight had average dust levels below 3.0 mg/m^3, whereas three occupations sampled below 2.0 mg/m^3 at the time of the original survey. Current data indicate that all occupations have average dust concentrations of less than 3.0 mg/m^3. Of the 21 occupations initially surveyed, only four have average concentrations exceeding 2.0 mg/m^3 and these only range to 2.5 mg/m^3.

When the respirable dust in the mine atmosphere contains more than 5 percent quartz, the operator must maintain the average concentration at or below a concentration computed by dividing the percent of quartz into the number 10. The result of this calculation may not result in a concentration in excess of any standard previously established by the Act.

Approximately 99 percent of the samples collected in the face areas of the mines contain 5 percent quartz or less; 79 percent contain less than 2 percent quartz. This corroborates the previous estimate of approximately 2 percent of quartz in the respirable dust encountered in the working areas of operating coal mines.

The data presented clearly indicate that the first level of the Federal respirable dust standards is attainable at this time. Many mines are now demonstrating that coal can be mined without exposing the workers to excess concentrations of respirable dust and that there is real promise for achieving the 2.0 mg/m^3 standard when it becomes effective after December 30, 1972.

THE PREVALENCE OF COAL WORKERS' PNEUMOCONIOSIS

by

Earle P. Shoub[1]

INTRODUCTION

This discussion will describe two current studies of the prevalence of coal workers' pneumoconiosis among working coal miners at underground mines in the United States. In both cases, the chest X-ray is the instrument for determining and categorizing the disease. Because the two studies differ materially in the composition of the sample, in the procedures for obtaining a final interpretation of the X-ray, and in the quality of the films, it is not surprising that there are some differences in the results. More important is that these differences are sufficient to make it highly inadvisable to consider merging the results in their present form.

A historical background for both studies is to be found in the work of Lainhart and others (2-3)[2] of the Public Health Service carried out from 1963 to 1965. At that time, the ILO (1958) system for classifying pneumoconiosis was generally accepted as the appropriate means of categorizing the disease. There were two features to this system which have a bearing on any effort to compare these results with subsequent studies. First, there was a "Z" or suspect category. Second, the "1" or irregular opacities were not to be considered in evaluating the profusion of disease. In more recently adopted systems for classifying pneumoconiosis, the suspect category has been eliminated and irregular opacities are included in the evaluation of profusion.

Another difference which may have a bearing was in the method of selecting the sample. For the 1963-65 studies, a roster of the working coal miners at Union mines was obtained and a random sample selected from it. Participation, although voluntary, was well over 90 percent.

Overall, at that time (table 1) it was reported that 85.5 percent were negative, 6.1 percent suspect, and 8.3 percent had definite disease. Subsequently, a reexamination of a sample of the X-rays in the suspect category indicated that about one-half were negative. This seems to mean that between 11 and 11-1/2 percent of the men examined had coal workers' pneumoconiosis to some degree.

The Bureau of Mines was aware of and provided some assistance to the Public Health Service in carrying out this prevalence study. Also, while it was going on, the Bureau of Mines, in 1965, assessed the methods of dust measurement and the exposure standards in many countries (5). It was

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[1]Deputy director, Appalachian Laboratory for Occupational Respiratory Diseases, Morgantown, W. Va.

[2]Underlined numbers in parentheses refer to items in the list of references at the end of this paper.

concluded at that time that gravimetric sampling was desirable with portable devices which would measure the fraction of the airborne particles accepted as significant by the 1959 Johannesburg Pneumoconiosis Conference (5). Also, in April 1968, a study was initiated to evaluate the dust exposure of miners in various categories of work in underground coal mines employing various mining methods. In all, 29 mines (1) were studied in depth. Dust levels were frequently found to be in excess of 3 milligrams of respirable dust per cubic meter of air especially among face workers.

TABLE 1. - 1963-65 study, bituminous mines only

Area	Number in selected sample	Percent participation	Category, percent			
			0	Suspect Z	Simple 1,2,3	Complicated
Appalachia	2,751	92.7	84.9	5.3	6.8	3.0
Illinois-Indiana	520	91.7	78.5	15.4	4.6	1.5
Utah	591	97.5	94.3	1.9	3.1	0.7
Total	3,862	93.5	85.5	6.1	5.9	2.4

The 29 mines were chosen by the Bureau of Mines after consultation with the Public Health Service, whose Bureau of Occupational Safety and Health (now the National Institute for Occupational Safety and Health) was planning a new prevalence study at as many of the same selected mines as would meet its criteria. This National Study of Coal Workers' Pneumoconiosis would, for the first time, have available to it, gravimetric dust measurements for comparison with the occurrence of disease and, more important, would be the basis for a continuing study in the same mines of the progression of pneumoconiosis in the miners in terms of elapsed time and dust exposures.

NATIONAL STUDY OF COAL WORKERS' PNEUMOCONIOSIS

The National Study of Coal Workers' Pneumoconiosis was begun in August 1969, more than 4 months before the Federal Coal Mine Health and Safety Act of 1969 became law. Thirty-one underground coal mines, including two anthracite mines, in 10 States were selected. About 20 of the mines in this study were among the 29 mines at which dust measurements were made by the Bureau of Mines. The lack of congruence was due to some mines having been closed or expecting to be closed, a desire to include mines in a few additional States, and a desire to concentrate on larger mines (over 100 employees).

The examinations, in this case, included chest X-rays (two views), simple breathing tests, and a detailed medical and occupational history. The X-rays were to be classified by the newly developed 1968 UICC-Cincinnati Classification system by each of three nationally recognized physicians. This system, it will be recalled, includes both regular and irregular opacities when estimating profusion of disease on a 12-point scale. This scale is depicted in table 2 in an abbreviated fashion. The interpretation relied upon, in each case, was based on agreement between at least two of the physicians. In a small percentage of the cases, a fourth interpretation was necessary to secure agreement between two readers of a film.

TABLE 2. - UICC-Cincinnati Classification system

Profusion	Categories			
Major.....	0	1	2	3
Minor.....	0/-, 0/0, 0/1	1/0, 1/1, 1/2	2/1, 2/2, 2/3	3/2, 3/3, 3/4

Fortunately, the protocol for the National Study of Coal Workers' Pneumoconiosis included all the details of the examinations authorized when the Federal Coal Mine Health and Safety Act of 1969 was enacted. The operators of the 31 mines were told that, as long as they made provisions for examining new miners employed after participating in the National Study of Coal Workers' Pneumoconiosis, it was not necessary for them to repeat the examinations under the regulations issued in accordance with the Act. As a result, the data collected in this study does not overlap similar data from another current study described later in this seminar.

It was recognized at the outset that part of the reliability of this study rested on securing a large voluntary participation by the miners. It was determined that an overall participation of 80 to 85 percent would be essential for reliable statistics. Table 3 shows the distribution of the mines and the degree of participation. It is gratifying to see that the total participation amounted to over 90 percent.

TABLE 3. - Distribution of mines and degree of participation
National Study of Coal Workers' Pneumoconiosis

State	Number of mines	Number of employees	Number of men examined	Percent participation
Pennsylvania, anthracite.....	2	608	523	86.0
Pennsylvania, bituminous.....	6	1,517	1,461	96.3
West Virginia.....	9	3,000	2,565	85.5
Virginia.....	2	613	560	91.4
Kentucky.....	3	1,035	959	92.7
Alabama.....	2	799	777	97.2
Indiana.....	1	297	274	92.3
Ohio.....	1	474	450	94.9
Illinois.....	2	671	524	78.1
Colorado.....	1	219	219	100.0
Utah.....	2	799	764	95.6
Total.....	31	10,032	9,076	90.5

The high rate of voluntary participation was the direct result of a concerted effort on the parts of the Public Health Service, the operators, and the United Mine Workers of America (UMWA). Numerous separate and combined meetings were held with mine officials, District and Local UMWA officers, and the men to be examined.

Final results (that is consensus readings), are now available for the 31 mines. Table 4 shows the prevalence of the disease by States found in the National Study of Coal Workers' Pneumoconiosis.

TABLE 4. - Prevalence of coal workers' pneumoconiosis, National Study of Coal Workers' Pneumoconiosis

State	Category of pneumoconiosis, percent				
	0	1	2	3	Complicated
Pennsylvania, anthracite	40.0	23.7	17.6	4.4	14.3
Pennsylvania, bituminous	53.1	31.8	11.7	1.1	2.3
West Virginia	72.0	19.8	5.3	0.4	2.5
Virginia	71.8	22.5	3.6	0.2	2.0
Kentucky	71.0	23.7	3.2	0.2	1.9
Alabama	83.3	12.7	2.7	0.1	1.2
Indiana	65.0	29.9	4.0	-0-	1.1
Ohio	68.2	24.9	5.8	0.4	0.7
Illinois	84.9	13.9	1.0	-0-	0.2
Colorado	95.4	4.6	-0-	-0-	-0-
Utah	88.7	10.3	0.3	-0-	0.7
Total bituminous	72.0	21.0	4.9	0.4	1.7
Total anthracite and bituminous	70.1	21.1	5.7	0.6	2.4

COAL MINE OPERATOR'S EXAMINATIONS

Section 203 of the Federal Coal Mine Health and Safety Act of 1969 and the regulations of August 19, 1970, issued under it require the operators of underground coal mines to make available to each miner in or at his mines an opportunity to have a chest X-ray at no cost to the miner. It is also provided that each new miner should be given a similar opportunity within 6 months of employment. Additional chest X-rays and other medical examinations specified by the Secretary of Health, Education, and Welfare are required at various intervals specified in the Act as determined by him. When, for any reason, a coal mine operator fails to provide an approvable plan for the examinations, the Act directs the Secretary to arrange for the examinations and to charge the operator the costs thereof.

The regulations required that each operator promptly submit a Coal Mine Operator's Plan for each of his underground mines which met the five following requirements:

1. The examinations be at no cost to the miners.

2. The place, time, and other arrangements for the examinations be convenient for the miners.

3. The results of the examination be kept confidential between each miner and the Government except as the miner might otherwise authorize.

4. The chest X-ray be made at a facility approved for the purpose by the Public Health Service. Facilities were approved if they submitted, as evidence of competence, six chest X-rays of good quality made in their office or clinic.

5. The chest X-ray be interpreted by an approved "A" reader and forwarded with the interpretation to the Receiving Center of the National Institute for Occupational Safety and Health in Morgantown, W. Va. The "A" readers could become approved either by attending one of several special 2-day courses of training or by submitting six chest X-rays of different degrees of pneumoconiosis which, in the opinion of a panel of experts, were properly classified by the applicant.

To provide for those instances in which operators failed to submit an acceptable plan, contracts were made with several organizations operating mobile X-ray units who met the same qualification requirements to take the X-rays for the Public Health Service.

The method of deciding upon the interpretation of the X-rays for pneumoconiosis in this study differs materially from the previously described one in that both the scheme and readers are different. There are about 800 "A" readers almost all of whom qualified by attending one of the 2-day courses. Each X-ray is first interpreted by one of the "A" readers and then the film and interpretation are sent to the Receiving Center. At this point, the film only is forwarded to one of the approximately 20 "B" readers selected on a rotating basis. The "B" readers are members of the Departments of Radiology at three major medical centers of the United States. If the "A" and "B" readers agree as to the major category of pneumoconiosis, the interpretation is accepted and final reports are prepared. On the other hand, when, as occurs in over one-quarter of the cases, these readers do not agree, the film is sent to a "C" reader whose opinion is final. The "C" readers are the department heads in radiology at the same three medical centers.

Not all of the films made by the end of the examining period (December 31, 1971) are completely interpreted. Some required retaking because of poor film quality, others were delayed before reaching the Receiving Center, and some are in transit to and from "C" readers.

All in all, there are about 64,000 films including retakes and duplicates. Some men have been examined more than once by their own choice. The number of miners involved is approximately 60,000. Final data are available on 56,731 men in 19 States as shown in table 5. In this table, there is incorporated an estimate of the category 0 cases represented by new miners and the cases in the same category from examining men who were in the industry when the Act was passed.

TABLE 5. - Prevalence of coal workers' pneumoconiosis coal mine operators' examinations

State	Coal workers' pneumoconiosis category, percent						
	Number final determinations	New miners 0	Other miners 0	1	2	3	Complicated
Pennsylvania, anthracite	984	-	67.8	18.1	7.7	0.7	5.7
Pennsylvania, bituminous	12,769	16.9	67.4	9.8	4.0	0.3	1.6
West Virginia	20,004	20.0	66.9	7.7	3.8	0.3	1.3
Virginia	4,466	16.3	74.1	6.1	2.2	0.3	1.0
Kentucky	10,185	13.8	77.1	6.8	1.6	0.2	0.5
Alabama	830	3.3	85.4	9.4	1.2	-0-	0.7
Tennessee	266	3.0	85.3	7.9	3.8	-0-	-0-
Maryland	39	10.3	71.8	15.4	2.6	-0-	-0-
Indiana	141	9.2	79.4	7.8	3.6	-0-	-0-
Ohio	2,029	39.3	54.9	4.1	1.2	0.1	0.5
Illinois	3,517	13.8	75.0	8.3	2.0	0.2	0.7
Colorado	722	19.0	76.6	2.8	1.1	0.1	0.4
Utah	593	2.2	89.9	5.7	1.2	-0-	0.8
Arkansas	27	-	77.8	18.5	-0-	-0-	3.7
Iowa	43	4.7	93.0	2.3	-0-	-0-	-0-
Montana	14	-	100.0	-0-	-0-	-0-	-0-
New Mexico	30	-	83.3	10.0	3.3	3.3	-0-
Oklahoma	20	25.0	70.0	5.0	-0-	-0-	-0-
Washington	19	-	100.0	-0-	-0-	-0-	-0-
Wyoming	33	15.2	78.8	3.0	3.0	-0-	-0-
Total bituminous	55,747	17.6	70.4	7.7	3.0	0.2	1.1
Total bituminous and anthracite	56,731	17.3	70.3	7.9	3.1	0.2	1.2

MINERS' RIGHTS UNDER THE ACT

Under the Federal Coal Mine Health and Safety Act and regulations, working coal miners with a sufficient amount of pneumoconiosis or impairment may exercise two rights which are to be called to the attention of each eligible miner by the Secretary of the Interior at the time he reports to the miner the findings with regard to coal workers' pneumoconiosis. One right is described in Title IV of the Act and in regulations issued by the Social Security Administration. It provided, during the period of the recent studies described herein, for the payment of Black Lung Benefits to any miner who applied if he (1) had X-ray evidence of complicated pneumoconiosis, or (2) had positive X-ray evidence of simple pneumoconiosis accompanied by sufficient respiratory impairment. The other right affords the miner, who has shown development of evidence of coal workers' pneumoconiosis, the option of transferring from his position to another position in the mine where the concentration of respirable dust in the mine atmosphere is not more than 2.0 milligrams of dust per cubic meter of air, without a reduction in his rate of pay, provided that the miner is not already working in such an atmosphere.

The Black Lung Benefits Act of 1970, Public Law 92-303, has liberalized the eligibility requirements for Black Lung Benefits. Also, the original Act provides that the 2.0 mg/m^3 limit shall be reduced to 1.0 mg/m^3 effective December 31, 1972. If, however, the 1.0-mg level is not attainable in the mine, the Act permits assigning a miner who has decided to exercise this right to work in a place in the mine where the concentration of respirable dust is the lowest attainable below 2.0 mg/m^3.

In his regulations, the Secretary of Health, Education, and Welfare has defined the points at which coal miners show sufficient evidence of pneumoconiosis to be eligible to exercise the transfer option, as follows:

1. Any miner who shows X-ray evidence of category 2 or 3 simple pneumoconiosis or complicated pneumoconiosis, or

2. any miner who shows X-ray evidence of category 1 simple pneumoconiosis in less than 10 years in coal mining.

There has been a great deal of interest shown in the matter of the number of miners eligible to utilize this option to transfer and how many have decided to take advantage of it. Table 6 presents the current statistics of miners eligible because of X-ray findings. This table does not indicate how many are already working in an atmosphere containing no more than 2.0 milligrams of respirable dust per cubic meter of air.

TABLE 6. - Number of miners eligible for transfer because of X-ray findings

Category of coal workers' pneumoconiosis	National study of coal workers' pneumoconiosis		Coal mine operators' examinations		Total	
	Number of men	Percent of men examined	Number of men	Percent of men examined	Number of men	Percent of men examined
1 in less than 10 years.	183	2.0	495	0.9	678	1.0
2 [redacted].	514	5.7	1,745	3.1	2,259	3.4
3 [redacted].	57	0.6	133	0.2	190	0.3
Complicated.....	219	2.4	668	1.2	887	1.3
Total.....	973	10.7	3,041	5.4	4,014	6.0

Miners who decide to request transfer apply directly to the Bureau of Mines. The Bureau notifies the operator to make the transfer unless the miner is already employed in an atmosphere where the respirable dust level is not in excess of 2.0 milligrams per cubic meter of air. A total of 567 applications from working miners have, so far, been approved. This amounts to less than 1 percent of the 65,807 men reported on herein and slightly over 14 percent of the 4,014 men in the same group who are eligible because of the X-ray findings.

FUTURE PLANS

We are presently in the process of comparing the data assembled in the National Study of Coal Workers' Pneumoconiosis with the dust levels which existed during the working life of the same miners prior to the X-ray examinations. The same data will be related to the miners' age and years in mining.

The Act requires that the miners again be offered an opportunity to have a medical examination, including a chest X-ray, 3 years after the first opportunity. For the mines included in the National Study of Coal Workers' Pneumoconiosis, the second round is, therefore, just starting. The bulk of the miners who should come under Coal Mine Operators' Plans are expected to have their examinations beginning in calendar year 1973. In addition to reporting on their health to the miners and their physicians and to assembling prevalence data, similar to that included above, the second round of examinations in the National Study of Coal Workers' Pneumoconiosis will offer an opportunity to evaluate for each man the change in X-ray appearance over the period between examinations and to compare the results with his exposure to respirable dust during the same period. To provide a sufficient cohort for future examinations, the number of mines in this study is being increased to 39 or 40.

The examinations by the operators are expected to be modified slightly to provide information on the miners' occupational and medical history, as well as pertinent symptoms. It is also anticipated that there will be some simple breathing tests included.

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RESPIRATORY IMPAIRMENT IN WORKING COAL MINERS

by

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INTRODUCTION

It is fairly widely accepted that coal miners have a greater prevalence of respiratory disease than does the general population (1-2, 4).[2] The extent and cause of the excess of respiratory disease are still the subject of debate, but there seems little doubt that the geographical region in which the miner works has a bearing on the prevalence of respiratory symptoms and impairment. There are several factors that must be considered in the etiology of respiratory disease in coal miners. First, there are those related to his occupation per se, namely, coal mine dust and possibly other noxious agents to which he is exposed while at work. Secondly, there are the factors that are responsible for the development of naturally occurring respiratory diseases, such as, chronic obstructive airway disease, tuberculosis, and lung cancer, all of which also affect the general population and are clearly not work related.

Coal workers' pneumoconiosis (CWP) is a consequence of exposure to dust and there is little doubt that in its complicated form, it is associated with respiratory disability and premature death (3, 9). In contrast, simple CWP is associated with some minor respiratory impairments, which of themselves are not severe enough to be associated with respiratory disability (6). It is accepted by informed physicians that although the higher grades of simple pneumoconiosis (categories 2 and 3) produce little in the way of respiratory disability, there is an increased risk of miners with these categories developing the complicated form of the disease. Thus, simple pneumoconiosis, although relatively harmless by itself, is sometimes a precursor of serious disease, namely complicated pneumoconiosis.

There is some debate as to whether chronic nonspecific obstructive airway disease occurs more frequently in coal miners and, as already mentioned, investigations into the prevalence of airway obstruction and bronchitis in miners have produced contradictory results. Several Appalachian Laboratory for Occupational Respiratory Diseases (ALFORD) studies have a bearing on this problem and are worth description.

It is proposed in the remainder of this paper to describe the types of physiological respiratory impairment that are seen in coal miners, and to attempt to decide which of these impairments are related to coal mining and which to naturally occurring disease.

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[2]Underlined numbers in parentheses refer to items in the list of references at the end of this paper.

VENTILATORY CAPACITY

Most studies in Britain and the United States have shown that coal miners have a lower ventilatory capacity than that found in comparable groups of non-miners (1-2). In some studies, differences have been quite obvious and in others less so. Thus, Enterline was able to show a difference between coal miners and a comparable group of railway workers when he surveyed a random population in Mullens, W. Va. On the other hand, in Richwood, W. Va., his findings were equivocal and there was no real difference in the ventilatory capacity of the Richwood miners from that of the control population of lumber men (2). Preliminary analysis of the data that we have collected in the Interagency Study of Coal Workers' Pneumoconiosis shows similar inconsistencies. There is little doubt that anthracite miners have a lower ventilatory capacity than do either their bituminous counterparts or the normal population. Thus, their forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC), and residual volume (RV) all deviate significantly from the predicted figure and the extent of the deviation is related to their category of simple pneumoconiosis. In addition, anthracite miners have more bronchitis and more chest symptoms than do their bituminous colleagues and the excess of symptoms cannot be accounted for by their smoking habits (8). In the case of bituminous miners, those who come from central Pennsylvania, southern West Virginia, Virginia, eastern Kentucky, and Alabama seem to have an excess of respiratory symptoms but only a slight reduction of ventilatory capacity. Lacking a comparable control group, their mean spirometric values have been compared with the predicted figures of Kory and others (5). In general, they are slightly but significantly lower. In contrast, the comparable figures for miners from the Middle and Far West compare very favorably with the predicted figures and in some instances are significantly better. This is especially true in Utah and Colorado. Furthermore, there seems to be no obvious relationship between the extent of the ventilatory impairment and the category of simple pneumoconiosis except in the anthracite miners. As is to be expected, definite ventilatory impairment was present in progressive massive fibrosis (PMF). There seems therefore to be some evidence that in certain regions, there is a reduction of the ventilatory capacity of nonpneumoconiotic working miners over and above that produced by naturally occurring obstructive disease. The impairment that is a consequence of their occupation is not of sufficient severity to be associated with disability with the exception of that occurring in the anthracite miners from eastern Pennsylvania.

LUNG VOLUMES

Previous studies carried out in this laboratory have shown that the residual volume of the lungs of working miners is increased and that the extent of the increase is related to the radiographic category (7). This applies whether or not the miners have evidence of obstructive airway disease, and is present in nonsmokers. We feel that the increased residual volume is a consequence of obstruction in the small airways rather than focal emphysema.

DIFFUSING CAPACITY

The problems of measuring the diffusing capacity in a large group of subjects are those concerned with selection. In particular, there is the problem of excluding the effects of coincident, naturally occurring, obstructive airway disease. Similarly, it has been shown that cigarette smokers have small but significant abnormalities of their diffusing capacity and in order, therefore, to study the effects of coal workers' pneumoconiosis on the diffusing capacity, it is necessary to select a group of miners who are nonsmokers, who have no evidence of obstruction of the large airways, and who have no evidence of concomitant cardiopulmonary disease other than CWP. In a group of 30 nonsmoking miners with categories of 2 and 3 simple pneumoconiosis, we showed that none of them had a significant reduction of their diffusing capacity (10). There was a minor reduction in the mean values for diffusing capacity in the miners with the pinhead type of opacity as compared to those who had micronodular opacities. This reduction, however, was small and only significant when the two groups were considered as a whole.

DISTRIBUTION OF INSPIRED GAS

Previous studies carried out at the Appalachian Laboratory for Occupational Respiratory Disease (ALFORD), have shown that working and ex-coal miners with pneumoconiosis have minor abnormalities in the distribution of inspired gas (6). These consist of changes in the ratio of dead space to total volume and in the alveolar-arterial gradient for oxygen. In no instance were these abnormalities sufficiently large to be associated with disability.

ARTERIAL BLOODS

Simple pneumoconiosis by itself does not produce significant desaturation, although the latter is frequently present in the complicated form of the disease (6).

MECHANICS OF RESPIRATION

Past investigations carried out in ALFORD have shown that nonsmoking miners with simple pneumoconiosis demonstrate a fall in their compliance at high rates of breathing (9). Although this implies that there is an increased resistance to flow in the smaller airways, this finding cannot necessarily be equated with the presence of disability. Studies of compliance and the retractive forces of the lung have shown that they are usually little affected in simple pneumoconiosis. There is a tendency for some subjects to have a slight reduction in the retractive forces; a finding that can be attributed to the presence of focal emphysema (PMF). In PMF, especially of the more advanced stages, the lungs are much less distensible than normal, and the retractive forces are increased. The cardiopulmonary laboratory of ALFORD has also shown that the flow rates of miners with pneumoconiosis are somewhat reduced and the reduction is not always a consequence of low retractive forces. This finding is again compatible with the presence of small airway disease.

NONSPECIFIC OBSTRUCTIVE AIRWAY DISEASE

Up to now the various impairments that have been described are a consequence of CWP and can be clearly related to the inhalation of coal dust particles of the respirable range. As mentioned earlier, there is some evidence that nonspecific obstructive airway disease occurs more frequently in coal miners. While there is little doubt that cigarette smoking is preeminent in the etiology of this entity, nonetheless, studies of the prevalence of bronchitis in working miners have shown that in nonsmokers there is clearcut relationship between bronchitis and dust exposure. Thus, nonsmoking, face workers have a greater prevalence of bronchitis and a slightly lower ventilatory capacity than do their counterparts who work on the surface. In smokers, the effects of dust exposure are overwhelmed by the effects of cigarette smoking and no discernible trend is evident. Furthermore, the presence of bronchitis does not seem to be related to radiographic evidence of coal workers' pneumoconiosis. There is good reason to assume that the type of dust which is responsible for the development of bronchitis differs from that which is responsible for the production of CWP. Bronchitis by definition implies a disorder of the mucous glands and goblet cells present in the conducting system of airways. Few particles in the respirable range are deposited in these airways, and it seems that dust induced bronchitis is more likely to be an effect of the deposition of larger particles in the conducting system, namely, those between 5 and 15 microns. Unfortunately, the Bureau of Mines is not making total dust measurements and is confining itself to making measurements of dust particles in the respirable range. It would seem desirable to correct this omission.

In addition to the chronic effects of dust exposure, studies carried out by Dr. Lapp and his colleagues have shown that there is an acute effect of coal dust exposure. In a study carried out by ALFORD personnel, it was shown that the ventilatory capacity of miners declined following a work shift. Further experiments using similar techniques and which relate changes in function to prevailing dust levels are desirable.

Although much is understood concerning the development and effects of pneumoconiosis and other respiratory impairments in coal miners, much still remains to be done in this field. The effect of coal dust on the smaller conducting airways is only just starting to be investigated and there is room for great expansion in this field. Similarly, it is becoming apparent that both the prevalence of pneumoconiosis and the prevalence of respiratory impairment differ in various geographical regions. At present no real explanation for these differences exist. This may be a consequence of physical or chemical composition of coal dust to which the men are exposed, and appropriate studies to unravel these problems could profitably be carried out by the Bureau of Mines.

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THE NATIONAL COAL WORKERS' AUTOPSY STUDY

by

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Section 203(d) of the Federal Coal Mine Health and Safety Act of 1969 authorizes the Department of Health, Education, and Welfare to perform research on pneumoconiosis and to undertake an autopsy study. The responsibility for this project was entrusted to the Bureau of Occupational Safety and Health, which has since become the National Institute for Occupational Safety and Health. Initially, the autopsy study was planned as a strict research study, obtaining maximum data from a few medical centers, where special techniques would be performed to detailed standards. Later, following the coal mine disaster in Hyden, Ky., in December 1970, the need for a general autopsy study was realized. The planned research autopsy study became a separate project and a larger national program of autopsies of coal miners done by private pathologists was planned. The program was formulated with consultation of the Social Security Administration, the Armed Forces Institute of Pathology, the College of American Pathologists, the American Society of Clinical Pathologists, and the medical support of the United Mine Workers. The final protocol was published as a regulation in the Federal Register of May 14, 1971.

An explanation of the program, the program protocol, a sample of a personal history form, a reprint of the official autopsy protocol, and a return postcard were mailed to approximately 10,000 pathologists listed by the American Medical Association and to 60 pathologists listed by the American College of Osteopathic Pathologists. The program was also publicized by a presentation at the American Society of Clinical Pathologists' fall meeting on October 27, 1971, by editorials in all leading pathology journals, and by an article submitted to the Archives of Pathology.

The pathology section at the Appalachian Laboratory for Occupational Respiratory Diseases (ALFORD) has a threefold function--that of research in pneumoconiosis and other occupational respiratory diseases, a service program which is the National Coal Workers' Autopsy Study, and a responsibility to insure that miners killed in mine disasters may be autopsied.

The National Coal Workers' Autopsy Study is basically a service program to aid surviving relatives of miners in establishing claims for Black Lung Benefits through the Disability Insurance Program with the Social Security Administration. This program guarantees payment up to $200.00, with an additional $10.00 if a chest X-ray and report are submitted, to the pathologist. Such payment is used to encourage the participation of pathologists and is also especially useful to compensate for professional services when an autopsy is requested for miners who die outside the hospital. Participation requires

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that the survivor fill out a short, simple form listing a history of occupational exposure, the miner's main occupation and last occupation, a smoking history, and the name of the last mine worked in, as well as the number of years worked. The form also includes a statement assuring the person permitting the autopsy that if he or she ever wants the information to be released, the Public Health Service will cooperate. It is also specifically stated in the form that no payment is to be made for the autopsy by the consenting party. The autopsy should be performed by an accepted autopsy procedure, such as that described by the Armed Forces Institute of Pathology Autopsy Manual. The pathology section of ALFORD has a limited number of these manuals which may be borrowed by the pathologists for a brief period. Upon receipt of the forms, the autopsy protocol, tissue blocks, and slides, payment is issued. Thus, the National Coal Workers' Autopsy Study is a general study applicable to all pathologists throughout the country. It is designed to be a straightforward project not requiring any specialized equipment or extended effort which might discourage participation.

There has been increasing participation by pathologists throughout the Nation. In the first year, there were only 68 cases submitted, and in the second year, 203 cases were submitted. Of the cases, 77.3 percent are from the Appalachian bituminous coalfields and 9 percent are from the Western coalfields of Utah, Oklahoma, New Mexico, Colorado, and Wyoming.

The cases submitted comprise a useful range of coal miners. The population has an average age of 64 with a range from 36 to 88 (standard deviation of 11 years). The average time working underground was 30 years with a standard deviation of 14 years but a range of 1 year to 65 years. Nearly all jobs are represented. Sixty percent of the men worked at the face of the mine in jobs such as continuous miner operator and coal loader. Fourteen percent of the men never worked in a mine with modern mining machinery.

The main cause of death was vascular disease such as arteriosclerotic heart disease or a cerebral vascular accident (40 percent), followed by nonmalignant lung diseases (20 percent), and malignant diseases of all types (23 percent). Nine percent died with lung cancer. Accidents and violent deaths accounted for only 2.3 percent. Approximately half of the men (50.1 percent) were either nonsmokers or very light smokers (less than one pack year for their lifetime). Twenty percent (20 percent) of the men were heavy smokers of over 30 pack years for their lifetime.

In general, we have a fairly representative sample of the Nation's coal mining population. The degree of coal dust exposure ranges from men who have worked only 1 or 2 years in the mines to others that have worked over 65 years in the mines. We have smoking histories, job histories, and geographical locations to correlate with autopsy data. We are currently studying new methods to quantitate lung disease.

The research study of the laboratory has many facets. Tissues and information obtained through the National Coal Workers' Autopsy Study are used to study the causes of death of miners as well as a general range of lesions produced by coal workers' pneumoconiosis. The electron microscope and the

molecular probe are used to study the ultrastructure of the lungs and the elemental analysis of dust particles within the lung. Another study is determining the correlation between the extent of the tissue damage due to dust and the appearance of the lungs by X-ray. Post mortem physiological studies are being performed to determine the extent of tissue damage which is detectable by physiologic studies. The research aspects of the pathologic studies will lead to a greater understanding of the structure and function of lungs as well as the reaction of lungs to dust and chemicals.

The third function of the laboratory is to insure that an autopsy service is available to miners killed in disasters. The three pathologists in the section are prepared to assist at any disaster. In the case of mine disasters, the pathology section is notified by the Bureau of Mines by an answering service "hot line." At this time, the pathology section contacts responsible parties at the scene of an accident and determines the extent of the disaster and informs the people of the availability of autopsy services. The team will go to the disaster site prior to the recovery of the bodies to make whatever local arrangements may be needed with pathologists, hospitals, the coroner, and the widows or next-of-kin.

The usual procedure would be to contact the Social Security Administration's local office which, in most cases, has a local representative at the scene of the disaster. The United Mine Workers Welfare and Retirement Fund officers, usually physicians, are also routinely at the scene of the disaster. These people largely have the trust of the miners' families and can advise the families of the desirability of having their relatives autopsied. A call is usually made to the county prosecutor's office or the county coroner to insure that the civil government cooperates in this procedure. However, the success of the disaster autopsy study depends upon the ability to obtain permission for the autopsy from the widow within a reasonable time after death.

The need for carrying out a full autopsy and an analysis on all miners killed or injured as a result of a mine accident cannot be overemphasized. The use of forensic autopsies in investigating aircraft accidents has now become a routine procedure and has contributed to increased aircraft safety. In such cases, the Federal Aviation Agency (FAA) works in cooperation with private pathologists in seeing that autopsies are done on essentially all individuals killed in aircraft accidents. The FAA has the authority to order autopsies if the local authorities will not do so. A similar program would be valuable for investigating mine accidents. Such a program would detail the causes of death in mine accidents and help in the development of means to prevent these deaths.

HEALTH ENGINEERING RESEARCH

by

Joseph J. Yancik[1]

Ancient mining literature contains numerous references to "bad air" and "corrosive dusts." Agricola, the Father of Mining, often wrote about these two scourges and called them "Widow makers." Unquestionably, the miner today is exposed to far less "bad air" and "corrosive dusts" than his forebearers. Nevertheless, here in the 20th century these environmental hazards still exist. However, real hope can now be openly expressed because of Public Law 91-173. In this law, our Nation's research and development resources have been dedicated to give every miner a chance to live out his natural life, a life not cut painfully short by a debilitating "miner's" disease.

As directed by Public Law 91-173, the Secretaries of the Departments of the Interior and Health, Education, and Welfare are charged with the conduct of studies, research, experiments, and demonstrations to improve working conditions and practices in coal mines to prevent accidents and occupational diseases. The Bureau of Mines, since its creation in 1910 by Public Law 179, has had a continuous history of health and safety responsibilities, responsibilities which have been frequently delineated by legislative acts. Through the years, the Bureau has concentrated on engineering aspects of health problems caused by environmental factors. Closer cooperation has been sought out and achieved with many public health agencies and services. The Bureau, if it is to carry out its health and safety research responsibilities under Public Law 91-173, must maintain and strengthen these medical liaisons. Mining research has dedicated itself to do just that. The environmental health research activities of the Bureau, under Public Law 91-173, range over a wide area. They are primarily centered in the engineering aspects of health problems created either by underground environmental conditions or by the mining equipment working in this environment. Frequently, these two factors are so interdependent that they cannot be meaningfully studied as separate entities. Safety engineering is often so intimately involved that only a systems approach offers any reasonable chance of success.

By far the largest effort of the Bureau is devoted to the elimination of respirable dust in the mine atmosphere. Other programs relate to noise problems, toxic gases from blasting, fires, and in-situ noxious contaminates, protective personnel equipment, mine ventilation, and induced health problems caused by mining equipment and materials used in the extraction processes. In each of these programs, a well-balanced research effort between long range and immediate goals has been achieved largely as a result of the "Inherently Safe Mining Systems Contract." This multimillion dollar contract will incorporate and demonstrate, in a year-long effort, not only safety technology but also all the latest health engineering technology that exists.

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Significant findings and research accomplishments have already been made under our Public Law 91-173 environmental research program. Planning is now underway to get these results into the ISMS underground demonstration. These achievements will be briefly discussed as will be the status of prime elements of the programs in noise, industrial hygiene, and respirable dust.

NOISE RESEARCH PROGRAM

Two valuable contributions to noise control technology have been the Bureau of Mines development of a personal audiodosimeter and a discriminatory ear muff. Both devices are now undergoing field evaluations and should soon be available for industry use.

Audiodosimeter

The personal pocket-size, permissible, audiodosimeter assesses an individual's exposure to intermittent noise over a working shift. When the dosimeter is connected to its readout device, the following data are available: Percentage of maximum permissible exposure, any exposure greater than 115 dBA, serial number of the dosimeter, and condition of the dosimeter batteries. This information determines whether an individual's exposure to noise is within the maximum noise level-time exposures specified by the Coal Mine Health and Safety Act of 1969. No such instrument was available when the Act became law. A number of companies are interested in manufacturing this dosimeter. Other devices using the Bureau-developed design are now available and are being evaluated.

Ear Protective Device

The discriminating ear protective device will permit a wearer to hear low-level warning signals, but still provide protection from sounds in excess of 90 dBA. If our underground evaluations are satisfactory, the device will provide the needed interim means to protect personnel from noise until techniques to control the noise from mining machines are developed.

Drill Noise Problems

Noise from percussive roof drills is a most serious problem both in terms of levels near or in excess of 115 dBA and in terms of time exposure. Research has come up with two prototype mufflers and a drill case which are being tested underground.

This noise control system installed on a percussive drill reduced the sound level from 115 to 101 dBA. At this reduced noise level operation of the drill in compliance with the standards is now 2 hours as compared with the quarter hour limit for the drill before modification. More testing is needed to conform the commercial use of this system.

Reduction of noise levels in face mining machinery is also a critical problem. Undertaken have been studies to assess the nature and source of generated noise from continuous miners, loaders, and rotary roof bolters. We hope to secure data and information that will define corrective measures.

Other Problems

Maximum noise levels permitting effective communication between personnel need to be defined. Studies are in progress under a grant to examine noise sources and warning signals in underground coal mines that effect communication and mine hazard warning signals.

Summary of Noise Program

The noise program has been funded in thousands of dollars, as follows, since 1970:

Fiscal year 1970	Fiscal year 1971	Fiscal year 1972	Projected fiscal year 1973
0	93.8	429.6	399

The significant results of the noise program include the development of a personal audiodosimeter, the development of a discriminating ear protective device, and, finally, the development of a noise control system for a percussive drill that reduces sound level from 115 to 101 decibels. The program has attained certain milestones during its short life. Intermittent noise exposure standards have been defined. Noise sources for surface operations have been identified. Projected is the future lowering of the noise level limit for an 8-hour workday, and determination of the peak exposure of miners to noise environments.

INDUSTRIAL HYGIENE RESEARCH

Research in the field of industrial hygiene has concentrated on toxic gases and materials, and diesel engines.

Diesels

A significant amount of research and development effort has been concentrated on the problems involving the use of diesel-powered equipment underground. This work has been divided into two general areas, (1) the development of methods of reducing toxic materials resulting from the operation of diesel engines and (2) the development of alarm and monitoring systems for diesel engines.

Studies on engine emission control have indicated that neither a water scrubber nor an oxidization catalyst has any significant effect on oxides of nitrogen emissions. The use of exhaust gas recirculation plus oxidization catalysts will, however, reduce both nitrogen oxides and carbon monoxide levels. Engine operational parameters affecting toxic gas emissions have been determined and methods of reducing engine emissions by variation of these parameters are being developed.

Development of an alarm and monitor system that will warn of increasing concentrations of toxic gases in the vicinity of the diesel-powered equipment

has been designed. A carbon dioxide detector monitoring intake air of the diesel engine will detect exhaust rebreathing of the engine and automatically shut off the engine. Previous research on engine emission control had shown a well-defined relationship between the level of carbon monoxide in the exhaust gas and the level of carbon dioxide in the intake air. This work is now concentrated on finding a detector that can be mounted directly on the engine and withstand the severe vibration.

Actual in-mine experience with diesel-powered equipment will be obtained under a cooperative agreement with a Kentucky coal company. This study will evaluate the effects of various engine operating parameters on exhaust emissions and operating data on engine alarms and monitors.

Other Problems Needing Attention

Research areas that need more attention and study include (1) methods for predicting toxic fume concentrations from explosives; (2) new explosives systems with low toxic fumes; (3) toxic and noxious products from thermal decomposition of fire extinguishants; (4) analytical methods for surveillance of mine air composition; (5) coal mine combustion products identification and analysis; (6) individual and area mine air monitors to provide continuing surveillance of mine environment; and (7) development and demonstration of prototype sampling instrumentation systems incorporating small sample analysis technique perfected in fiscal year 1972.

An improved computer code has shown promise in predicting explosives. Field verification of these results could lead to the development of new low-toxicity explosive formulations, a significant advance since small, low-seam coal mines need better explosives.

It is a known paradox that the introduction of a new technique or piece of equipment intended to solve a specific health and safety problem create new problems. A good example is chemical fire extinguishers which are designed to put out small fires before they become major, man-killing blazes. These extinguishers have proven to be very effective in stopping small fires at the source. However, if these extinguishers are not used at the outset of a small fire, their major use may itself become a danger to the miners.

Halon concentrations required for inerting methane-air mixtures are in the range of 3.5 to 7.0 percent Halon. Halon acids are extremely toxic; hence the need for fire extinguishment with a minimum quantity of Halon is obvious. Full-scale in-mine experiments have been initiated to test the validity of laboratory inerting results and to provide guidance on proper extinguishment procedures.

We are also concerned with toxic fumes given off from the combustion of fire-resistant materials used in coal mines. Carbon monoxide presents greatest toxic hazard during combustion of various chlorinated conveyor belt materials, but relatively high levels of HC are also possible when dilution effects are small. Obviously, this research confirms the necessity of providing extremely good ventilation in occupied working areas while fighting even small fires.

Summary of Industrial Hygiene Program

The industrial hygiene program has been funded in thousands of dollars since 1970, as follows:

Program	Fiscal year 1970	Fiscal year 1971	Fiscal year 1972	Projected fiscal year 1973
Toxic gases and materials.....	98.0	209.0	433.1	402.5
Diesels.....	0	350.0	318.0	260.0

The significant results of the industrial hygiene program include the development of a prototype CO_2 alarm for diesel intake, the determination of fire-resistant material toxicity, and the advancements made in diesel engine emission control. Further research is necessary to develop explosives with low toxic fumes, analytical methods, and improved mine air monitors.

RESPIRABLE DUST

Program goals in our respirable dust program have been as follows:

1. The immediate goals were to optimize the use of water sprays and ventilation to suppress and control respirable coal dust, and then to implement the use of foams, machine-mounted dust collectors, and advanced water spray systems.

2. The mid-range goals were to use existing fundamental technology to modify the presently used mining equipment, and to develop techniques for preventing the formation of respirable dust at face and transfer points.

3. The long-range goal was to conduct fundamental studies on fracture mechanisms and on dust formation and capture phenomena by coal types and the dynamics of ventilation at the face.

4. The overall goal was to design new and improved mining systems which inherently prevent and/or more effectively control dust levels.

Major results and progress will now be covered.

Prevention

Two main studies to prevent the generation of dust when cutting coal are preconditioning--that is water infusion--of the coalbed prior to mining, and machine parameter modification. In addition work is progressing on hydraulic jet mining and water stemming of shotholes.

Although more recent work in this country on water infusion was initiated for methane control it has been expanded to consider its applicability to the prevention and control of respirable dust.

Underground testing has been completed at three locations: the Federal No. 2 mine of Eastern Associated and Consolidation's Leverage mine both in the Pittsburgh seam, and the Beatrice No. 3 plow in the Pocahontas seam.

Briefly, infusion involves prewetting the coal before mining. Injection holes are drilled ahead of the face and water is injected until breakthrough occurs at the face.

Marked visible reduction was obtained in float dust, and methane levels were reduced in the Pittsburgh seam at Leverage mine. Respirable dust reduction was marginable. At the Federal No. 2 Leverage mine, which is adjacent to the Leverage mine, the coal face was trickle infused, a variation in technique, and respirable dust was significantly reduced. Dust was also significantly reduced in the Pocahontas seam. This work is being continued since it has major promise.

A full-scale continuous miner is being specially designed and built to study the means of reducing the quantity of respirable dust generated during the coal cutting cycle. This machine will have pick speeds of 100, 200, and 500 feet per minute and cutting depths from 1 to 5 inches. The head can take picks or bits of two different rake angles and spaced at 1½, 2½, or 3½ times the depth of cut. There are six varying sump and shear speeds from ½ to 5 inches per second, and automatic sump and shear cycle controls. It will be tested underground at Clinchfield's Mars No. 3 mine. This is a new mine, which has a complete section dedicated to this work.

Backup development research is being done to support this machine parameter work. Although the British did pioneering work on machine parameters back in the 1960's, the work was not directed toward respirable dust. The Bureau of Mines Twin Cities Mining Research Center (TCMRC) at Minneapolis, Minn., has, therefore, become deeply involved in this type of work.

Backup basic work to support these field trials is underway at TCMRC on single event fractures by impact, sharp wedge cleavage, and variable-rate shear and crushing. The objective is to develop a comprehensive mathematical formulation, either empirical or rigorous, that will describe the fracture process as verified by in-mine results.

Since water stemming of shotholes and hydraulic jet mining are minimally funded studies, results have been limited to lab data collection.

Suppression

Where dust is generated suppression techniques are designed to prevent its becoming airborne. A three-pronged attack includes water flushed bits, foams, and water sprays.

The water flushed bit is not new. About 40 water flush machines, of various manufacturers, are in use underground, but none that we know of are being used in the water flush mode. There are various reasons for this, but the main cause seems to be lack of satisfactory rotary pressure seal. Under

Bureau contract, a Lee-Norse[2] miner is being modified for underground testing. An identical machine without the water flushed bits will be used alternately in the same section for real time comparisons. Industry interest is high and, if successful, this technology should be quickly extended to other manufacturers' machines.

Foam for dust suppression, like water flushed bits, is not new. It has been sparsely investigated for at least 10 years. In the past 2 years three contracts on foam have been let; Monsanto and MSA have worked on applications of foam at the face; and Deter on a system for transfer points. The basic idea is to blanket the mined coal with a fast-breaking foam that will capture dust and wet it sufficiently to prevent its becoming airborne.

Although the Deter system for coal transfer points does a good job at suppressing dust, the economics are unfavorable. Both the MSA and Monsanto projects produced data that show some respirable dust reduction. Results unfortunately are not conclusive. We will soon begin another field trial with the Monsanto system that should tell us if foam is worth pursuing. It should be pointed out that the Monsanto and Deter studies are Bureau sponsored while the MSA study is sponsored by HEW.

Water Sprays

Water sprays are the present mainstay in control of float and respirable dust. There is a continuing effort by industry to adapt and improve water spray designs and techniques. Consequently, the Bureau effort has been small in this area. The Pittsburgh Mine Safety Research Center (PMSRC) at Bruceton, Pa., is continuously testing and evaluating sprays, both steam and water. They concluded that steam is no more effective in dust suppression than water. An empirical formula has been formulated that will give optimum selection of type and size of nozzles to match flow rate and water pressure. They are now working on a rigorous mathematical treatment for optimizing sprays.

Bituminous Coal Research has checked out and evaluated some of the knockdown efficiency claims for atomizing sprays and compared the results with conventional sprays. They found that the atomizing sprays did, in fact, do a better job of suppressing dust than conventional sprays. This work is also continuing.

Control and Collection

While water is a mainstay for dust suppression, ventilating air is the primary element for dust control. An adjunct to ventilation is dust collection. One of the first contracts funded by the Bureau following the Act was a study of the applicability of commercially available dust collectors to respirable dust problems. This study concluded that none of the commercially available units, that were tested, were really suitable for underground coal mine use. This information spurred industry to such a degree that several

[2] Reference to specific makes of equipment is used for identification only and does not imply endorsement by the Bureau of Mines.

devices have now been developed and are on the market. Yet to be confirmed is that they solve some of the dust control problems.

A cooperative study underway with Clinchfield Coal is designed to alleviate the horrendous dust problems associated with auger type miners. The approach is to try to control the dust by lowering the chain conveyor and pulling dust laden air through the center of the unit to a dust collector.

PMSRC has built an auger mine-face model in the laboratory to simulate flow conditions to help visualize, as well as analyze, change in geometrical configurations. Bituminous Coal Research is also involved in a contract with the State of Pennsylvania to evaluate dust collectors in use underground as a means of controlling dust.

We think it is safe to say that all of the collectors available for use underground will do an excellent job on float dust. Their efficacy on respirable dust remains to be verified.

The "why" and "wherefore" of coal-dust formation have never been fully understood. The Bruceton multifaceted study is centering on the phenomena of agglomeration. We have learned that only a small portion of the dust generated ever becomes airborne. Enough dust is generated in mining 1 kilogram of coal to contaminate 400 cubic meters of air to the 2 milligram per cubic meter level. If it were not that most of this dust sticks to the coal we would be in serious trouble. If we could understand the mechanism of adhesion and then adapt and use this knowledge we might lick the dust problem completely.

Summary of Respirable Dust Program

The respirable dust program has been funded in thousands of dollars, as follows, since 1970:

Program	Fiscal year 1970	Fiscal year 1971	Fiscal year 1972	Proposed fiscal year 1973
Prevention	539.9	889.0	910.1	1,302.0
Control	539.4	476.3	524.4	965.0
Personal protection	32.0	88.9	171.5	175.0
Analytical	334.6	390.0	414.1	270.0
Fundamental	430.1	765.5	511.9	620.0
Total	1,876.0	2,607.7	2,532.0	3,332.0
Grand total through fiscal year 1973	-	-	-	[1] 10,349.7

[1] Of the grand total, in-house expenditures will total $3,879.8 thousand (37.5 percent) and contract expenditures will total $6,469.9 thousand (62.5 percent).

Program accomplishments have been as follows:

1. The underground application of water infusion techniques,

2. Foam at transfer points,

3. Spray optimization and theory model,

4. Rejection of steam for control,

5. Potential dust problem (20 coal/10^6 ft^3),

6. Scanning electron microscope observation of untreated wet-lung,

7. Soft X-ray and infrared for quartz analysis,

8. Water flushed bits underground,

9. Machine parameters underway, and

10. 20 publications.

MINING RESEARCH TECHNOLOGY TRANSFER PROGRAM

When Congress enacted the 1969 Coal Mine Health and Safety Act it provided the funds to carry out health and safety research programs. Carrying out this research to successful completion is only half the job. The other half is to get these new or improved technologies into practice in our Nation's coal mines. To accomplish this most difficult task we are rapidly expanding and accelerating our mining research technology transfer program, the objective of which is to introduce and accelerate the use of research results to minimize or eliminate unsafe and unhealthful practices.

Through this program, operators and miners will get hands-on experience with new technology. We have already started the technology transfer process in our safety research program. Late in 1972 we will begin our technology transfer program in health engineering research. The research accomplishments highlighted in this report will constitute the early technology transfer efforts.

RESPIRATOR REQUIREMENTS AND PRACTICES

by

Jeremiah R. Lynch[1]

The purpose of this paper is to discuss the requirements of law with respect to nonemergency respirator use, the need for respirators in various situations that occur in coal mining, and the results of a study of the use or nonuse of respirators, together with some comments on the attitudes toward respirators and the reasons why they are or are not used. Based on this information, the solutions for some of these problems will be offered. These include the development of respirators which will meet the needs and the requirements of law and the development of programs, standards, and regulations which will provide for and require their use.

Section 202(h) of the Federal Coal Mine Health and Safety Act of 1969 states that "Respiratory equipment approved by the Secretary of the Interior and the Secretary of Health, Education, and Welfare shall be made available to all persons whenever exposed to concentrations of respirable dust in excess of the levels required to be maintained under this Act. Use of respirators shall not be substituted for environmental control measures in the active workings. Each operator shall maintain a supply of respiratory equipment adequate to deal with the occurrences of concentrations of respirable dust in the mine atmosphere in excess of the levels required to be maintained under this Act."

Section 204 states that "The dust resulting from drilling in rock shall be controlled by use of permissible dust collectors, or by water or water with a wetting agent, or by ventilation, or by any other method approved by the Secretary which is at least as effective in controlling such dust. Respiratory equipment approved by the Secretary and the Secretary of Health, Education, and Welfare shall be provided persons exposed for short periods to inhalation hazards from gas, dust, fumes, or mist. When the exposure is for prolonged periods, other measures to protect such persons or to reduce the hazards shall be taken."

It seems clear, therefore, that the use of respirators in certain instances is required in coal mining. These instances are, first, whenever respirable dust exceeds the limits prescribed by the standard, and secondly, for short periods, in the case of rock drilling, or other occasions when hazards of inhalation of gas, dust, fumes, or mist occur. With respect to the first instance (Section 202 h), it is obvious that at the times when a respirator is required, the mine operator will also be in violation of the standards. Since all violations of the standards must be abated sooner or later, or the mine will be closed, the question arises when would respirators be required? There are situations, however, when the mine operator knows that

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for some special reason he is in violation of the standard but that this violation has not yet been detected by the operator's sampling program or by a periodic inspection by Bureau of Mines inspectors. Similarly, when a violation of the respirable dust standard is detected, a period of abatement is generally permitted, during which time it is likely that, for at least part of the time, the standard will continue to be exceeded. During these periods, the law requires that respirators be used. Similarly, the law requires that respirators be used for short exposures to all air contaminants other than coal dust.

To interpret the various provisions of the Act with regard to respirator use and nonuse consistently, it would be necessary to say that respirators must be used for protection against respirable dust whenever the operator has reason to believe, either based upon his own experience or upon data or citations resulting from his own samples or samples collected by the Bureau of Mines, that he is exceeding the respirable dust standard. However, simultaneously he is required to develop and implement the engineering controls required to abate that respirable dust excess. It is not clear whether a combination of engineering controls and respiratory protection would be permitted. If, for example, it is possible for a mine operator, in special circumstances, to develop ventilation and other controls so as to reduce the dust from a level of perhaps 15 mg/m^3 down to a level of 5 mg/m^3, and if he could further reduce the exposure of the miner from 5 mg/m^3 to much less than 2 mg/m^3 by means of respiratory protection, does this meet the requirements of Section 202(h)? In other words, in this example, is respiratory protection being substituted for engineering control or is it being used in conjunction with engineering controls? At this time, this alternative has not been promoted for a variety of reasons.

It was our hypothesis that the respiratory practices in coal mines that existed at the time the law was passed and in the immediate aftermath were such that respirators would not be satisfactory for the protection of miners. To confirm or reject this hypothesis and to develop the engineering and psychological data base upon which a satisfactory respiratory program could be based, the National Institute for Occupational Safety and Health (NIOSH) contracted with the Eastern Associated Coal Corp. to study respirator practices in coal mines. Without going into the details of the rather lengthy reports resulting from this study, I would like to summarize a few of their findings. Virtually all mines made respirators available. Also, in virtually all mines their use was voluntary on the part of the miner. The miner's use of the respirator was related to his perception of the dust (and the risk from the dust) as modified by the attitude of the mine operator toward safety and health in general. Almost universally, respirators are worn on an intermittent basis.

The data from this survey is based on intensive interviews with 428 people in various job classifications, plus 17 section foremen, for a total of 445 men. It was found that 20 to 60 percent of the miners, as shown in table 1, used a respirator occasionally, depending upon the attitude and program of the mine operator, but almost no miner used a respirator continuously. Of those who used them occasionally, over 40 percent, as shown in table 2, used them as much as 3 hours per day.

TABLE 1. - Range of respirator possession and use (47 mines)

Respirator use	Approximate percent of underground work force
Possession of a respirator:	
High	90+
Low	40
Worn by work force:[1]	
High	60
Low	20

[1] Sometime during shift (see table 2 for duration of use).

TABLE 2. - Duration of respirator use

Hours per shift	Percent of underground work force interviewed
0-2	22
2-3	35
3-5	29
>5	14
Total	100

It is interesting to look at the question of what the miners thought should be done, as opposed to what they actually did. Fully 99 percent felt that respirators were needed for some occasions and should be worn when needed (table 3). Only 1 percent thought it possible to lower the dust concentrations so that respirators would not be needed at any time.

TABLE 3. - Need for use of respirators in coal mines

Category	Percent of underground work force
Generally needed	42
Used whenever dust is present	45
Used only when necessary	4
Needed, but are hard to wear	8
Prevent dust to make use unnecessary	1
Total	100

These results are not greatly different from what would be expected, except that the use of respirators was somewhat more extensive than anticipated, since it was expected that there would be almost no use. It was indeed surprising that most miners, although they did not wear respirators, felt that respirators should be worn.

Why don't miners wear respirators when they believe they should? The answer came, at least in part, from a series of questions that were asked with regard to respirator acceptability. About 35 percent of miners found respirators marginally acceptable or unacceptable and, in giving this response, they were thinking in terms of only intermittent, not continuous, use.

Reasons given for the unacceptability of respirators (table 4) were largely based on inconvenience and discomfort. The most frequently cited problems were breathing resistance (37 percent) and physical discomfort, meaning pressure on the face and head, sweat on the face, inability to chew tobacco, tightness of the harness (55 percent). A few (9 percent) of the miners stated that the respirator interfered with their work. Typical comments were: "It's hard to breathe. I feel smothered, especially when I'm doing hard work." Miners who, for one reason or another, suffered upper respiratory impairment were especially conscious of the need to wear a respirator, but unfortunately these individuals had the greatest difficulty wearing one.

TABLE 4. - Problems associated with respirator use

Category	Number of men	Percent of underground work force
Cause breathing difficulties	-	37
Physical discomfort	-	55
Generally cumbersome and uncomfortable	13	-
Cause perspiration	9	-
Interfere with tobacco chewing	9	-
Troublesome head harness	7	-
Respirator too large	6	-
Facepiece troublesome	5	-
Dust inside mask	5	-
Improper fit	1	-
Interference with work	-	9
Restricts vision or interferes with wearing glasses	5	-
Exhalation valve troublesome	2	-
Interferes with communications	1	-
Difficult to carry	1	-
Total	-	[1] 101

[1] Total adds to 101 percent because of rounding.

It can be concluded from all of the foregoing that, in a considerable number of instances, the use of respirators is required by law, that the miners themselves believe that respirators need to be worn, and that the miners are not wearing them principally because the respirators available to them are not satisfactory. Without exception, these respirators were of the quarter-face-mask type shown in figure 1. Respirators of this style provide very satisfactory protection in the dust levels, and for the kind of dust, encountered in a coal mine when properly used. In order for them to fit properly, it is necessary that they be tight and the pressure of the straps and facepiece can be painful. Also, the rubber facepiece traps sweat between it and the skin, the sweat mixes with dust and the resulting irritation becomes objectionable. The filters are not large, and the work of breathing is significant even when the filters are clean. It is apparent, therefore, that before we can effectively implement the provisions of the law to require the use of respirators in instances where the respirable dust and other dust, mist, and gases are temporarily exceeding the limits, and before we can even consider the use of respirators in conjunction with engineering controls as a means of reducing miner exposure to safe limits, better respirators are needed.

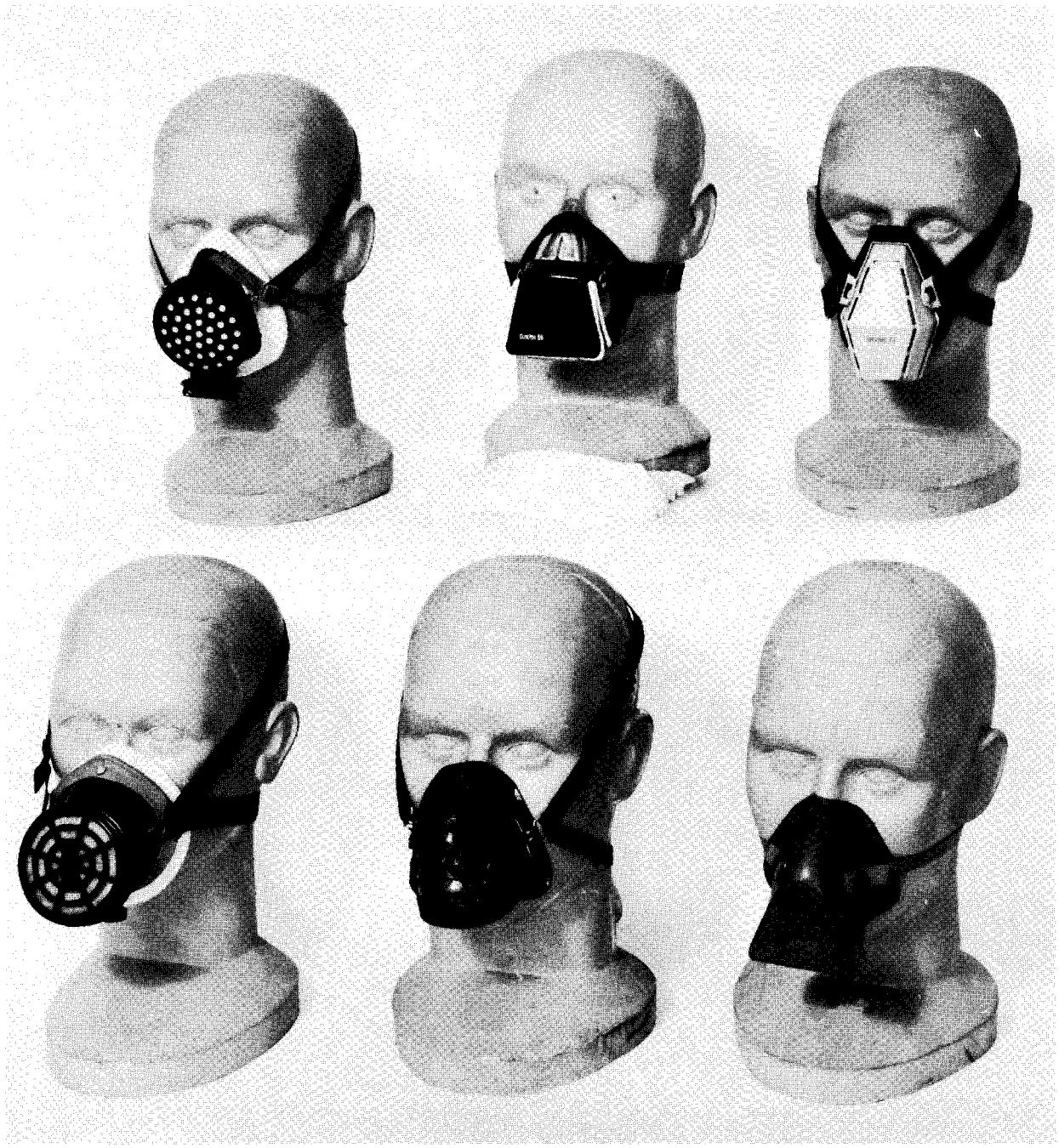

FIGURE 1. - Quarter Mask Dust Respirators. *(Courtesy, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.)*

NIOSH, the Bureau of Mines, and a number of other organizations are currently engaging in research and development activities aimed at providing respirators that will overcome the objections previously discussed and provide the worker with effective and acceptable protection. These activities are proceeding simultaneously in two directions. The first is the development,

testing, and certification of single-use respirators which, at least partially, solve the problem of facial irritation, harness tightness, and breathing burden (fig. 2). Respirators of this type provide a somewhat lower protection than the reusable quarter-face masks previously discussed, but they offer a number of advantages. They are lighter and do not require as strong a headband. The surface against the face is made of fabric or filter material which is less irritating than rubber and which does not trap sweat. Furthermore, the whole respirator is a filter; consequently, the filter is quite large and the breathing resistance is low. Since they are not used for more than one shift, they require no maintenance. An obvious difficulty is that the respirator has no exhalation valve and consequently the miner rebreathes his own exhaled breath to a slight extent. Since this was found objectionable in some instances, it is necessary to further evaluate the acceptability of devices of this sort. Although they are very inexpensive, since they may be used for only one workshift, the total expense may be greater than for conventional types of respirators. The new respirator testing and certification regulation, 30 CFR Part 11, dated March 25, 1972, provides for the approval of these new valveless single-use respirators. At least one model has already been approved.

The research direction in coal mine respirator development is toward the design of powered air-purifying respirators. Although the single-use respirator differed from the conventional half-face masks in that it was simpler,

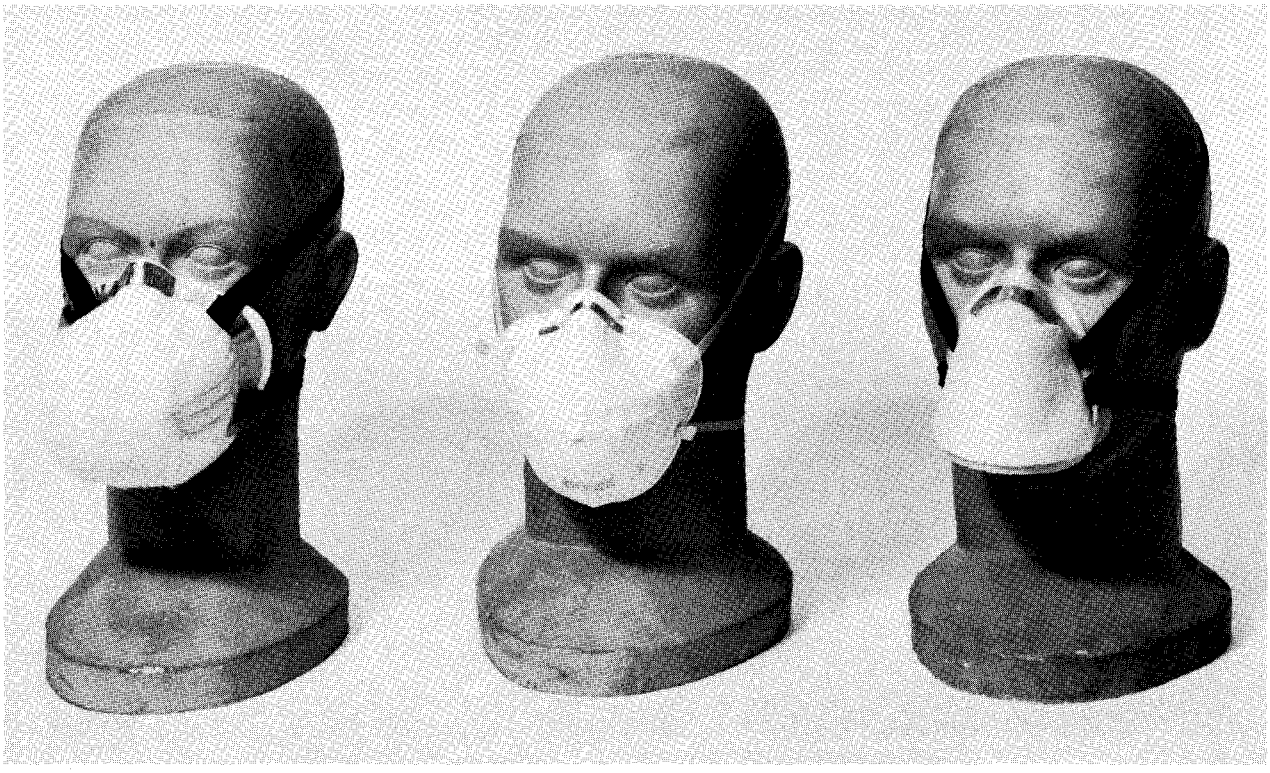

FIGURE 2. - Single-Use Dust Respirators. *(Courtesy, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.)*

FIGURE 3. - Powered Air-Purifying Respirator (C.S. Draper Laboratory).

these devices lie at the other end of the spectrum in terms of complexity. It is interesting to note that development of one type or another of these devices was instituted almost simultaneously, or at least within a short period of time, by the Bureau of Mines, NIOSH, Allegheny River Mining Co. (fig. 3), Harvard University, and several commercial firms, including 3M Co. (fig. 4),[2] Mine Safety Appliances Co., and others both in this country and abroad (figs 5-6). All of these devices have certain basic attributes. They all use an external power source other than the miner's lungs to overcome the filter resistance. The power sources range from battery packs to hydraulically operated prime movers connected to the mining machine. They all confront the problem of the fit of the face mask, although a variety of different approaches are used. The Bureau of Mines prototype, which is to be developed under contract with the Donaldson Co., provides a curtain of air blown down over the miner's face from beneath the rim of his hat. The Allegheny River Mining Co. device, under development by the Draper Laboratory of the Massachusetts Institute of Technology, is fundamentally similar, except that in addition to the hat, a helmet visor (face shield) which comes down almost to the chin and encloses the curtain of air, protects the clean airflow from interference by cross drafts. Environmental Systems uses basically the same approach as the Draper design, except that they use a hood rather than a helmet and face shield. Other designs

[2]Mention of specific manufacturers does not imply endorsement by the Bureau of Mines.

FIGURE 4. - Powered Air-Purifying Respirator (3M Co.).

FIGURE 5. - Powered Air-Purifying Respirator (Martindale).

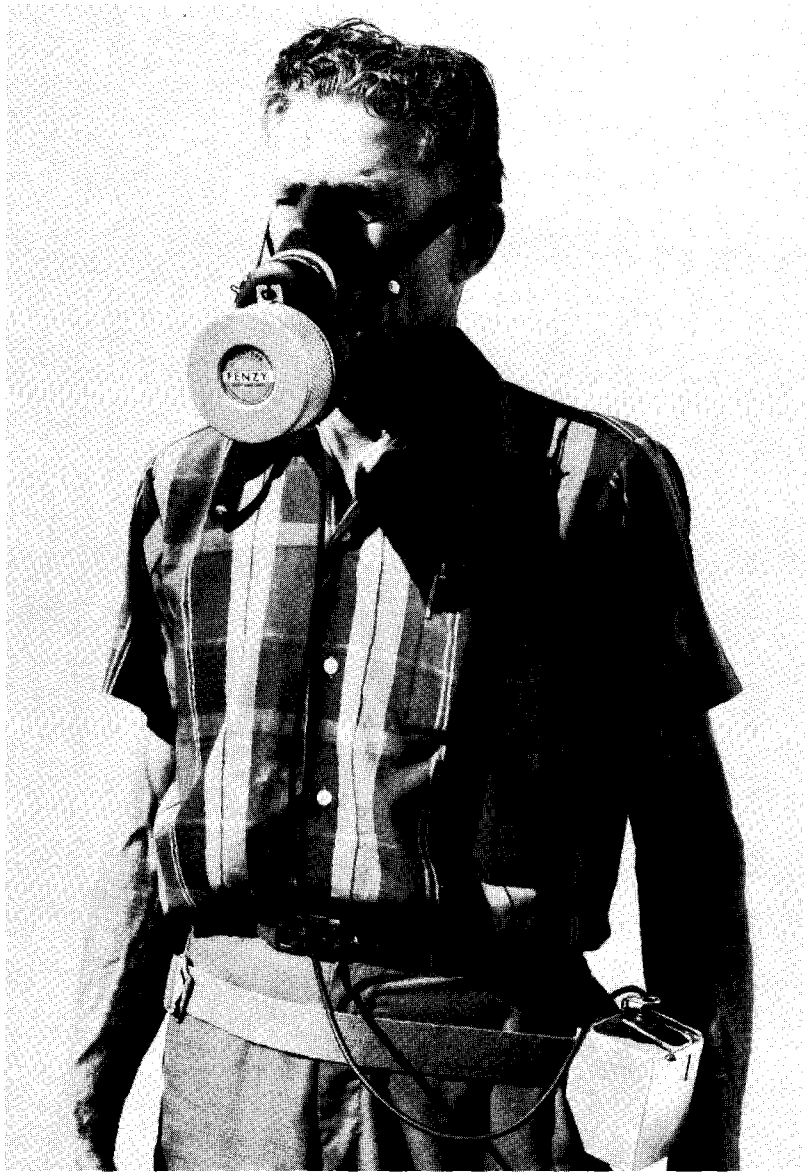

FIGURE 6. - Powered Air-Purifying Respirator (Fenzy).

use full-face masks and half-face masks. However, even though these masks are essentially identical to those used with previously unsatisfactory respirators, they can be made much more satisfactory in a powered air-purifying respirator. Since a tight fit is not required in the powered respirator because a positive pressure is being maintained in the respiratory inlet, any leakage from a loose fit will be outward. Again, since these are powered respirators, the filter resistance need not be overcome by lung power and the work of breathing is less. The obvious disadvantage is the increased weight (about 4 or 5 pounds) which the miner must carry.

We have every reason to believe that these dual developments will be at least partially successful. We are proceeding under contract to evaluate the 10 air-purifying devices currently available, either on the market or as prototypes. Each attribute will be evaluated so as to come up with a composite prototype design that will be as nearly satisfactory as the present state of the art can make it. Similar efforts will be undertaken to evaluate the single-use respirators.

Based on the outcome of these studies, NIOSH may recommend to the Bureau of Mines that the standards be modified to provide and encourage the use of these devices, at least in the intermittent exposure situation and perhaps even in those cases where the impact of conventional respirable dust abatement techniques is excessive and where it is possible to develop a program to protect the health of the miner using respiratory protection in conjunction with engineering controls.

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