TECHNICAL SESSION - II

RESEARCH IN COAL MINE HEALTH

"Overview of Bureau of Mines Health Research"

by

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ABSTRACT

An overview of Bureau of Mines health-related research is given; the three principal program areas are Noise, Respirable Dust, and Industrial Hygiene. The review includes current program objectives, a representative cross section of ongoing projects, and a listing of final reports that are available.

INTRODUCTION

The Federal Coal Mine Health and Safety Act of 1969 (Public Law 91-173), hereafter referred to as the Act, mandated certain health-related protection to the miners, such as the statutory provisions of Sec. 202 where maximum respirable dust levels were established. Additionally, numerous rules and regulations have been promulgated, such as those pertaining to maximum noise exposure (Title 30 CFR §70.510). The Act clearly identifies, in Sec. 501, the research responsibilities of the Secretary of the Interior and the Secretary of Health, Education, and Welfare (HEW) relative to coal mine health research. Basically, physiological and epidemiological studies such as determination of the causes of pneumoconiosis, the determination of the effect of certain noise levels on miners, etc., fall under the responsibility of the Secretary of HEW. The Secretary of the Interior's health research activity (which has been assigned to the Bureau of Mines) is directed toward the identification of problem areas, development and assessment of engineering controls of existing or potential health hazards and development and evaluation of instrumentation to quantitatively measure the presence and extent of the hazard. The following is a brief description

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of completed and ongoing project areas, with reference to some, but not necessarily all, projects in that area. In the appendix is a listing of all ongoing and completed projects with National Technical Information Service (NTIS) numbers for the final reports where they are available.

NOISE

The noise program is divided into three principal areas: (1) instrumentation, (2) personal protection, and (3) noise abatement.

In the area of instrumentation, the need exists to have a reliable and safe method of determining compliance with the maximum noise exposure criteria [§70.510 (a)]; since the exposure scale is nonlinear and the noise levels and duration are usually nonuniform, the procedure as identified in §75.506 calls for essentially full-shift monitoring to accurately determine full-shift exposure levels. To do this is difficult at best and in some cases presents safety problems when an observer is in the immediate work area.

As a result, the Bureau of Mines has conducted a comprehensive program on the development and evaluation of audio dosimeters. Functionally, an audio dosimeter consists of a sound level meter, a stop watch, a calculator--to determine the contribution of a particular noise level to the total daily dose--and an integrator, which sums all of the incremental doses for the shift. Initially, due to lack of a suitable instrument, the Bureau developed a dosimeter; then, as product lines were introduced, the commercial devices were evaluated for their performance [1, 2]*.

Because of the rapidly changing product lines of audio dosimeters, some of the devices have been updated and new ones introduced; therefore, a new evaluation was conducted in the spring of 1975; the results will be available shortly.

As of this writing, the Mining Enforcement and Safety Administration (MESA) has not promulgated a standard for the use of audio dosimeters for determining compliance in coal mines; such a standard is in effect for noncoal mines. However, when this option is available to the operators, the dosimeter can be a useful tool if used with care and as a supplement to but not a replacement for a good sound-level meter[2].

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*References refer to reports in Appendix A.

In addition to the work on the personal audio dosimeter previously described, the Bureau has developed a time-resolved audio dosimeter (Figure 1). While the conventional dosimeters give, at the end of the shift, the per cent of the maximum permissible exposure, the time resolved dosimeter at the end of the shift produces an amplitude time history of the worker's exposure for the shift (Figure 2). This tool permits a more accurate assessment of the nature of a worker's exposure for management control and for health surveys.

Also, in the instrumentation area, work is underway to develop an improved means of performing field calibration on audio dosimeters; such an instrument will permit more rapid calibration of dosimeters while maintaining the required accuracy.

In the area of personal protection, Sec. 206 of the Act states that in meeting the noise standard, the operator shall not require the use of any protective device or system, including personal devices, which the Secretary finds to be hazardous or to cause a hazard to the miners. This requirement of the Act raises a question about the suitability of ear muffs as a means of reducing a miner's exposure to noise; specifically, does the use of ear muffs jeopardize a miner's ability to hear warning signals such as roof talk, machinery, or other miners?

The ability of a miner to hear these warning signals with and without ear protection has been investigated under a Bureau-funded contract at Penn State University[3, 4]; briefly, the results show that at background noise levels in excess of 90 dbA, speech and warning signal discrimination is as good with ear protection as without it. However, when the background levels go below 90 dbA, the ear protection should be removed to maintain maximum warning signal discrimination.

Concurrently with this study, the Bureau was developing a discriminating ear muff[5] (Figure 3); this device is a set of commercially available ear muffs into which has been built an electronic intercom so that at low noise levels the miner hears, inside the muff, what is heard on the outside and at higher noise levels the signal transmitted through the muff is progressively attenuated. These devices have been evaluated by the same test procedure as the conventional ear muffs described above, and the results were quite encouraging. The discriminating ear muffs gave protection when required but permitted maximum warning signal discrimination at all levels. The prototypes have been also tested in coal mines and cleaning plants with generally favorable results. The discriminating ear muff has been demonstrated to be technically feasible but awaits production engineering before it can be commercially available to the industry. Recently, we have

FIGURE 1. Time-resolved audio dosimeter.

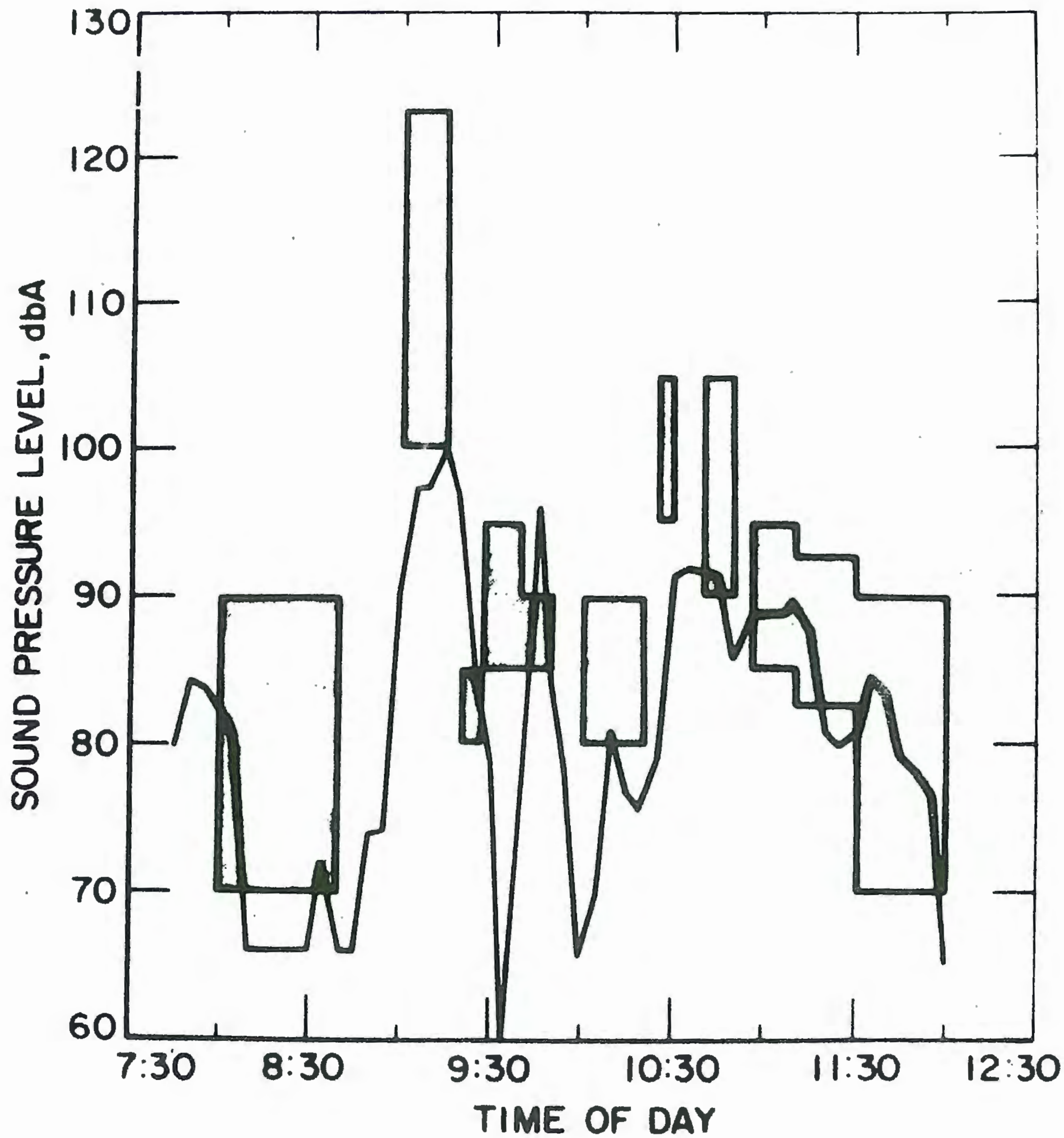

FIGURE 2. Typical output for time-resolved audio dosimeter.

FIGURE 3. Prototype discriminating ear muff.

located a similar device manufactured in England, (Cosmocord, Ltd., Acos Works, Eleanor Cross Road, Waltham Cross, England).

In the area of noise abatement, work has been directed toward pneumatic drills, electric face equipment, diesel haulage vehicles, and coal-cleaning plants. Although abatement is the most difficult of the three program areas, it is the most important in terms of compliance with the mandates of the Act.

With pneumatic drills, which typically produce 118 dbA, several approaches to noise control have been developed; in one instance, a muffler cover that can be fabricated in the field[6, 7] and weighs 5 pounds has been successful in reducing stoper noise to 102 dbA (Figure 4). While this is a significant reduction in some instances, further reduction is necessary for compliance with the noise standard; for these circumstances another type of enclosure has been developed under Bureau contract which reduces the overall stoper noise to 95 dbA[8, 9]. This system (Figure 5) adds 18 pounds to the weight of the drill. Currently, with the improvement in rotary mist drilling the Bureau, under contract, is evaluating the applicability of this technology to roof bolt drilling applications and compliance with mine noise standards.

Regarding electric face equipment, some progress has been made in the reduction of noise from a loader[10] where, with a number of modifications, some of which could not be done underground, the noise levels were reduced from 102 dbA to 95 dbA. Other efforts (see Table 1) are directed toward alternate designs to reduce loader and continuous miner noise. Additionally, contracts have been recently awarded to reduce continuous miner noise levels on ripper-type and auger-type miners.

Work has progressed in the identification and abatement of noise emissions from diesel-powered mining equipment[11]. In the case of personnel carrier, the levels were reduced from 102 to 87 dbA. The use of diesels in coal mines is limited at this time; however, with the possibility of increase use of diesels in the future in coal mines as well as noncoal mines, the current work on diesels is a significant step forward. This work has been funded under the Bureau noncoal program.

For coal preparation plants the Bureau has conducted investigations, under contract[12, 13], on the identification of noise sources and the development of corrective measures. Additional work was initiated in the abatement of chutes and screens; that work is nearing completion and recently a cost-sharing contract has been awarded to implement the noise control of a coal preparation plant. The project is expected to be completed in late 1975.

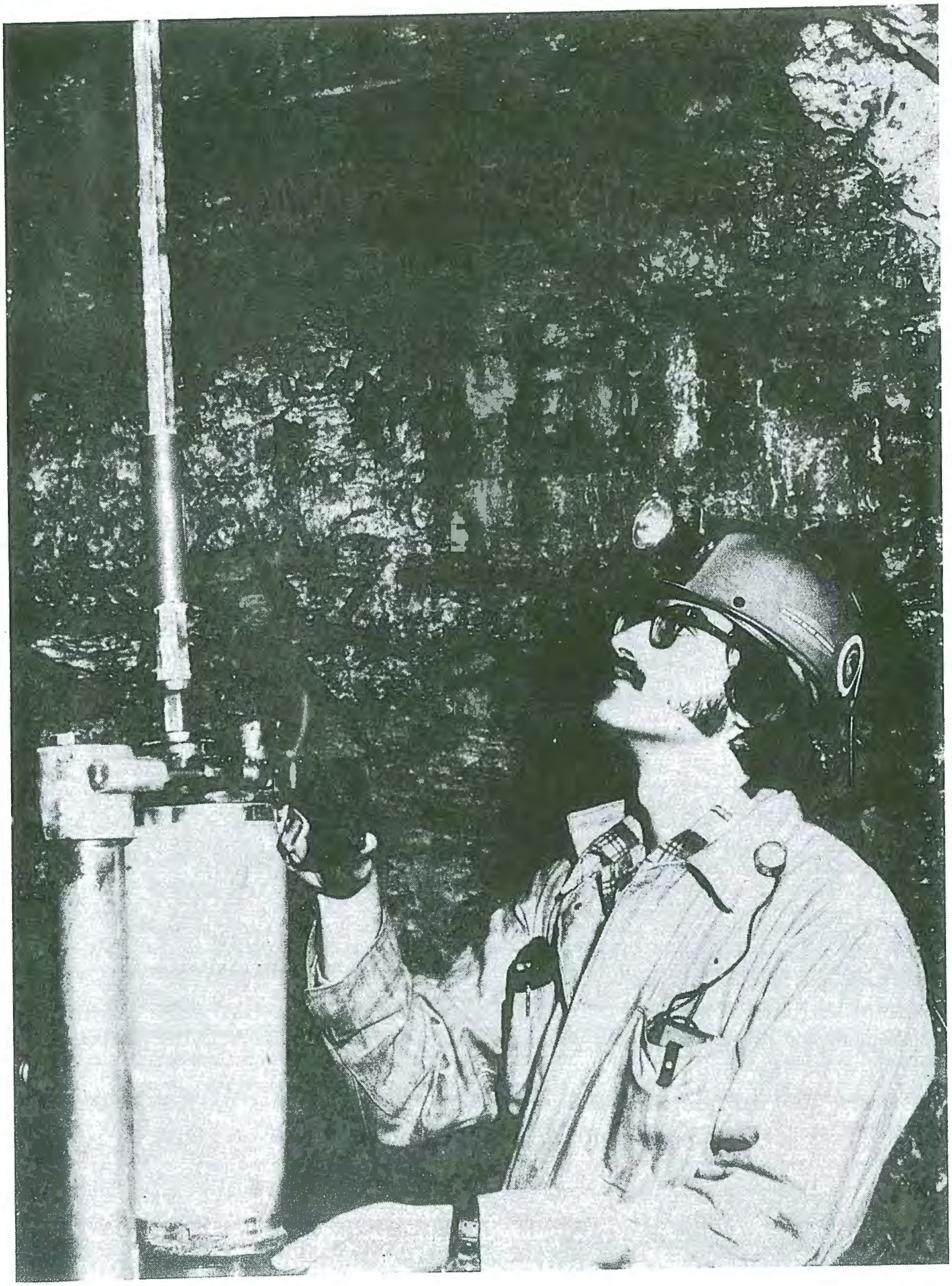

FIGURE 4. Pneumatic drill noise-control system that reduces levels to approximately 105 dbA.

FIGURE 5. Pneumatic drill noise control system that reduces levels to approximately 95 dbA.

TABLE I

SUMMARY OF BUREAU OF MINES
MACHINERY NOISE CONTROL PROGRAMS

Equipment Classification	Noise Control Program	Status
Roof Drills	Pneumatic Drill Noise	In-house
	Noise Control of Stoper Drill	Completed
	Development of Other Pneumatic Drills	On-going
	Evaluation of Wet-Head Drilling Techniques	On-going
Diesel-Powered Equipment	Noise of Diesel-Powered Underground Mining Equipment	Completed
Loading and Continuous Mining Machines	Noise Abatement in Mining Machinery	Completed
	Development of a Quiet Conveyor Designs for Mining Machinery	On-going
	Alternate Conveyor Designs for Mine Machinery	On-going
	Abatement of Noise of Continuous Miners	On-going
	Auger Miner Noise Control	On-going
Preparation Plants	Coal Cleaning Plant and Its Control	Completed
	Demonstrating the Noise Control of a Coal Preparation Plant	On-going
	Reduction of Noise from Chutes and Screens in Surface Mining Facilities	Completed

RESPIRABLE DUST

Respirable dust control is important for compliance with the statutory provisions of the Act and the protection of the workers. In terms of the cost of this country, black lung benefits totaled approximately $1 billion this past year. In the Bureau's Dust Research program, the major areas are identification of respirable dust characteristics, dust control at the face and outby, dust instrumentation, and personal protection. A more exhaustive review of the Bureau's dust work will soon be available[14].

The work on the characterization of respirable dust is an in-house program at the Bureau's Pittsburgh Mining and Safety Research Center (PMSRC) and resulted in a more comprehensive understanding of what "respirable dust" is and how to apply engineering controls to abate it. As an example, in a sample of respirable dust collected through a 10-mm cyclone and photographed with a scanning electron microscope, the sample contains many irregular-sized particles (some considerably larger than 5 μm) and a wide variety of minerals.

In the program of dust control, four areas are being attacked simultaneously: (1) machine design, (2) ventilation, (3) dust suppressors (water, steam, and foam), and (4) dust collection equipment.

Continuous-mining machines were designed to mine coal at a fast rate. They are very efficient mining machines. However, by using blunt, high-speed bits, they probably are the best machines for forming dust that could be invented, except for a grinding stone.

Bureau research has shown that continuous mining forms approximately 5,000 grams of respirable dust at the face per ton of mined coal. About 2 grams of this dust becomes airborne at the face, and the remainder adheres to the run-of-face broken coal.

The machine design work has been conducted in several areas: (1) a laboratory study of coal cutting and dust generation as a function of depth of penetration, bit rake angle, etc.; (2) a fieldworthy instrumented research miner specifically designed so that the cutting head speed, depth of cut, etc., can be accurately controlled over large ranges. Bureau laboratory studies have shown that the formation of airborne respirable dust drastically decreases as the depth of cut with the bit increases beyone one inch. Typically, the dust formed with a one-inch-deep cut is about 5 per cent that formed with a 1/4-inch-deep cut and about 20 per cent that formed with a 1/2-inch-deep cut.

A Bureau analysis of the crescent-shaped path of bits on the rotary hardhead[15] continuous-mining machines suggested that less than 1/2 inch, but that this shallow part of the total cut contributes about 85 per cent of the airborne respirable dust formed during the total cut. Thus, if the amount of coal being mined with less than a 1/2-inch-deep cut were reduced, the amount of airborne respirable dust would be very significantly reduced.

A research continuous mining machine having multiple bits on a single full-scale cutting wheel has been used as a "pilot plant" to investigate the effect of rpm and cutting depth. Results have confirmed that slow, deep cutting gives less dust.

The first two areas have been primarily used to develop the design parameters for the full size continuous miner. Based on preliminary tests, the optimum head speed may be 30 rpm and a 3-inch-deep cut.

In the area of ventilation, which has been one of the primary means of dust control, considerable effort has gone into quantitatively identifying the effectiveness of a properly engineered face ventilation system. In the case of a low coal auger miner as shown in Figure 6 where the model of the miner and the entry is 1/10 scale, the effect of proper ventilation can be seen with smoke used to simulate dust concentrations. In the left side of the figure the brattice cloth is set 10 feet from the face; notice the visual difference in the dust levels especially at the jack setter's or roof bolter's position. Quantitatively, the dust levels at this location were reduced by 80 per cent.

The use of secondary ventilation on an auger miner to reduce respirable dust levels has been developed under a cost-sharing contract with Clinchfield Coal Company. The conveyor was lowered on a 100L auger miner and two fans, with a total capacity of 5,000 cfm, were installed in the throat of the miner. With this arrangement the dust levels at the jack setter's position were reduced 90 per cent. Some problems have been encountered with dust generated on the conveyor outby the miner but with water sprays to allay this dust the exposure is less than 2.0 mg/m^3.

Concerning dust suppression with water, efforts have been directed toward the utilization of the water flushed bits on a drum-type continuous miner[16, 17]. Under contract, comparisons between the water-flushed bit "wet head" machine and a duplicate miner with conventional water sprays were made. Preliminary data shows a 30 per cent reduction of respirable dust at the machine operator with the water-flushed bit approach. However, there have been problems with the large diameter rotary seals in the head; after extensive lab investigations a suitable seal appears to have been found and full scale field tests will commence shortly.

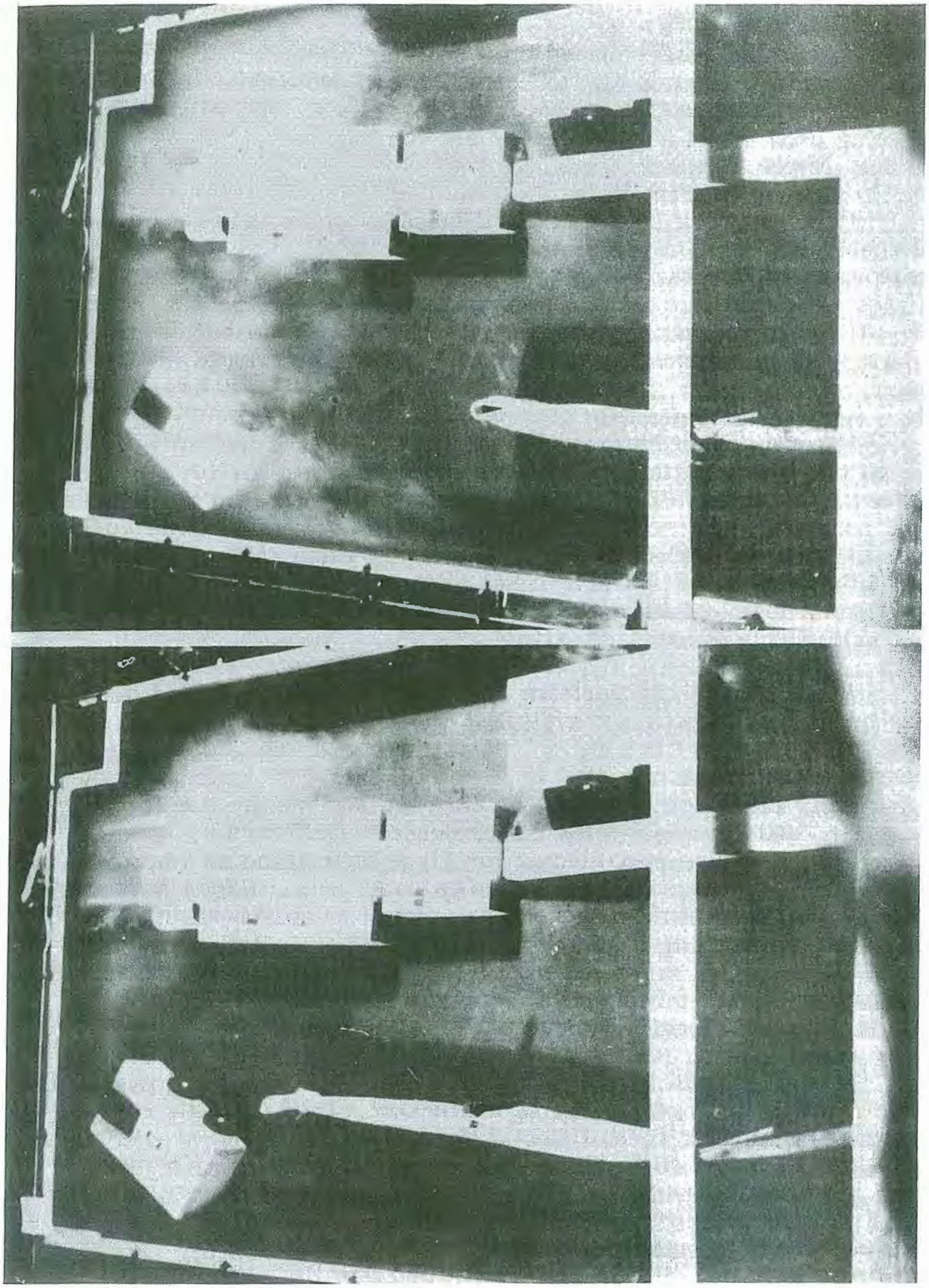

FIGURE 6. Effect of the position of the line curtain in control of dust levels in an auger miner section is shown where on the left the curtain is 10 feet from the face and on the right the curtain is 20 feet from the face.

Concerning water-flushed bits on auger miners, with the use of water through the shaft a 50- to 60-per cent reduction in respirable dust levels was obtained at the operator's position. This technology is now being used on 34 auger miners, and similar reductions in respirable dust levels have been obtained.

Work has been conducted on the use of water infusion to control respirable dust; in room-and-pillar operations a 30 per cent decrease was observed at the continous miner operator's position. In the case of longwall, a 70 per cent reduction was obtained at the tail gate. If the logistics of implementation on an operations face can be optimized, the technique appears to have promise for longwall operations.

Although water sprays on continuous miners have and will continue to play an important role in the suppression of airborne respirable dust, the spray efficiency is significantly affected by the location of the nozzles. In a series of experiments in a West Virginia coal mine, the original water sprays on top of the boom allayed 10 per cent of the airborne respirable dust; however, when an equivalent of sprays were installed below the boom, 50 per cent of the airborne respirable dust was captured.

Water sprays can perform effectively, but maintenance of the spray heads can be difficult; typically, 50 per cent of the sprays on a miner are clogged. Cleaning or replacement of a clogged nozzle is expensive to the mine operator in terms of time. A contract study of spray nozzle clogging indicated that clogging was mainly due to coal, pipe scale, and other particles that bypassed strainers in the water line. A cyclone-type precollector for large debris and an improved strainer were developed. Field tests in underground mines have demonstrated that spray maintenance requirements decrease about 90 per cent. The nonclogging system is available for an installed cost of about $600. In four mines the nozzle maintenance has been reduced 90 per cent. After three weeks of operation, only three of thirty nozzles had been clogged.

Several efforts have been conducted in developing and evaluating foam for the control of respirable dust[18, 19]. The Bureau-sponsored work has investigated three types in five mines; the general conclusion is that foam gives a 10 to 20 per cent decrease in respirable dust levels as compared with water sprays in face operations. In the control of respirable dust as secondary transfer points, foam does offer some interesting possibilities with reduction of up to 50 per cent observed.

Another potential means of respirable dust control is via dust collectors; the preferred secondary ventilation technique from a mining operation viewpoint is, of course, to use a machine-mounted dust collector whose effluent is dumped at the machine, thereby avoiding a cumbersome ducting to the return. In this case, a low-cfm system also minimizes recirculation problems, but a high-collection-efficiency dust collector is desirable in order to reduce the dust exposure of downstream personnel. A large assortment of available dust collectors were tested in 1970 but all were found unsatisfactory owing to a low collection efficiency for respirable-size dust or because of bulk or safety problems. The Bureau fabricated an aboveground facility to evaluate the collection efficiencies of prospective full-scale collectors as they become available. For example, the collection efficiency of a typical unit ranged from 80 per cent for 1 m dust. While surprisingly high, these efficiencies are frequently too low to scrub anticipated incoming dust levels to a 2-mg/m^3 level.

Extensive laboratory tests with a Bureau-developed 3, 000 cfm venturi collector indicated a collection efficiency for respirable dust of <90 per cent for anticipated operating conditions. Three commercially available scrubbers (DuPont, Merix, and Donaldson) built to Bureau specifications recently were laboratory tested. Results with the flooded-bed-type DuPont scrubber indicated higher collection efficiency than obtained to date with any other unit, e. g., 95 per cent observed with the venturi for the same operating conditions. As a result, the concentration of respirable dust in the effluent is one-half that obtained with the venturi. The cyclone-type Donaldson and Merix scrubbers demonstrated collection efficiencies of about 90+ per cent for comparable conditions.

The venturi, DuPont, Donaldson, and Merix collectors are low-cost, simple, compact, and have reasonably high dust collection efficiency and can use low-pressure water sprays with slurry water, but it usually needs a droplet eliminator and a somewhat lengthy transition ducting from the venturi throat to the eliminator. The venturi should be least susceptible to clogging. The cyclone-type Donaldson and Merix units have a more modest collection efficiency but appear especially suitable where low water use id desired. The flooded-bed DuPont unit has a very high efficiency with a low pressure drop but normally requires medium-pressure water sprays that may cause problems if dirty water is used; clogging of the media may also be a problem underground. The low pressure drop of the DuPont scrubber is especially attractive for an available 2, 000 cfm fan (Joy 5112) can then be used in the dust collector with several inches of pressure drop still being available for duct losses or reserve.

Selection of the specific collector for a specific underground application will depend upon available space, the desired collection efficiency, and water and clogging problems. Two 2,000-cfm collectors incorporating the Donaldson and Merix scrubbers were designed and fabricated by the Bureau. At present, these collectors are being installed on a Sagem longwall shearer for field tests. DuPont and wetted-fan collectors are being fabricated for installation onto a similar Sagem shearer. A venturi-type collector is presently being designed for a Goodman borer and a DuPont-type collector is being designed for a Jeffrey 100L.

In the area of instrumentation, several cost-sharing contracts have been awarded to the manufacturers of personal dust samplers to improve the performance and reliability of the current line of devices.

In the area of instantaneous reading respirable dust meters(20), an instrument that uses the back-scattered light-detection technique has been extensively tested in the field and has proven to be reliable for on-the-spot measurements.

In the area of personal protection, an air curtain helmet(21) that was developed under contract showed some promise to reduce personnel exposure when the operator was on a machine where the blower and filter could be mounted. The connecting hose was equipped with a breakaway coupler so that in the event of rapid egress from the machine the miner would not be tied down. While acceptance was limited because of the connecting hose, the device does reduce by 90 per cent the respirable dust exposure of a continuous-miner operator.

As an alternate approach, the air curtain has been installed in the top of a canopy (Figure 7) where, within a 19-inch square, operator protection is provided. The device uses 200 ft^3/min and has been demonstrated to be greater than 90-per cent efficient. The actual extent of the protection depends on how long the operator stays within the air curtain. In the system, which is being evaluated in four mines, it has been found that the operator with the air curtain is exposed to 30 to 70 per cent less respirable dust than a duplicate personal sampler mounted on the machine.

INDUSTRIAL HYGIENE

The industrial hygiene program is divided into three major program areas: (1) Toxic products, (2) instrumentation, and (3) diesels.

In the area of toxic products, the presence of toxic gases and vapors that may be produced as a result of mine fires is a major hazard to mining operations. Although many materials used underground, such as brattice cloths, conveyor belting, and hydraulic fluids have been approved as fire-resistant, the health hazards of the thermal decomposition of these materials until recently have never been determined.

FIGURE 7. Air curtain for control of exposure to respirable dust installed in machine canopy.

Under a Bureau-funded contract, the toxic materials produced by the thermal decomposition of thermally unstable materials is being identified and quantitatively analyzed[22-25]. Work to date indicates that the fire retardancy of some materials has been achieved at the expense of an increased toxic hazard. As an example, for conveyor belts, in addition to the expected products of CO and HCl, other highly toxic species are formed, such as chlorinated hydrocarbons, chlorinated aromatics, and COS.

The problem of toxic products from explosives has long been the concern of the Bureau of Mines; however, with new formulations of explosives rather than the traditional dynamites, new and improved evaluation methods are required and are under development for the determination of toxic fumes from all types of explosives.

A number of projects are directed toward the development and evaluation of instruments for the detection of toxic gases with principal emphasis on carbon monoxide and oxides of nitrogen[26, 27]. The instruments have two primary roles: (1) In area monitors where they must be portable but the size is not as critical as good performance over extended periods of time, and (2) for personal protection and/or monitoring where light weight and compactness are the primary parameters.

In the personal monitoring area, the detailed evaluation of the performance of stain tubes was recently completed and showed that stain tubes have an overall accuracy of $\pm$ 25 per cent[28, 29]; of this error, approximately $\pm$ 20 per cent was reader error, and only $\pm$ 5 per cent was due to the instrument itself. The Bureau is currently investigating the possibility of using a mechanical length of stain reader to minimize this error. Under this same project, a wide variety of personal monitoring devices including oxygen meters, carbon monoxide detectors, and methanometers were evaluated for accuracy and reproducibility in simulated coal mine atmospheres; most instruments performed within advertised specifications. Evaluation will continue this fiscal year with emphasis on electrochemical gas sensors for Co, NO_2, and criteria will be formulated for gas detector performance.

Several promising new instruments are under development for personal and portable monitoring and for personal dosimeters to monitor exposure to CO, NO, and NO_2, based on the molecular diffusion of the contaminant gas through a chemically selective trapping medium. The NO_2 dosimeter is ready for extensive field testing; CO is still under laboratory evaluation.

Other instrument developments include a portable CO detector based on electrochemical oxidation of carbon monoxide at a gold electrode; this instrument should give extended long-term stability compared with current CO detectors. Several approaches are being investigated that, if successful, would yield pocket-size instruments on alarms: one is based on electrochemical and fuel cell technology; the other is based on investigating the use of pressed powders of mixed metal oxides of the rare-earth perovskites, which may result in a sensor specific to CO. Another instrument is a portable battery-operated analyzer for use by mine and inspection personnel to measure CO, NO_2, and CH_4, which has less susceptibility to interferents that may be in the mine atmosphere.

In the area of diesels, projects are directed toward a more detailed assessment of the effect of diesels on coal mine air quality; under contract, an extensive atmospheric survey will be conducted of diesel exhaust emissions (CO, CO_2, NO, NO_2, low-molecular-weight hydrocarbons). Also the perfume of diesels under various operating conditions is being investigated in the laboratory, where parameters can be precisely controlled, and in the mine under actual operating conditions. On vehicle gas monitors, developed under previously funded Bureau contracts, programs are being used to collect data on the level of toxic emissions and whether a potential hazard exists.

The feasibility of using a char-filled cannister to trap the odors and sulfates of diesel exhaust are being investigated as well as the production of highly toxic sulfuric acid mists.

CONCLUSIONS

An overview of Bureau of Mines-funded research in Noise, Respirable Dust, and Industrial Hygiene has been presented. The Appendix provides details as to specific titles, contractors, and information on obtaining final reports where they are available.

APPENDIX A - REFERENCES

1. "Noise Dosimeter Performance" by Kenneth C. Stewart and Timothy Y. Yen. Bureau of Mines RI 7876, 1974, 39 pp.

2. "Instruments for Measuring Noise Exposure" by H. Kenneth Sacks. Proceedings of Bureau of Mines Technology Transfer Seminar on Noise Control, IC 8686, 1975, 108 pp.

3. "Aspects of Noise Generation and Hearing Protection in Underground Coal Mines." Final Report by Pennsylvania State University, Bureau of Mines grant GO122004, November 1972, OFR[3] 19-73, NTIS[4] 219 087.

4. "A Study of Roof Warning Signals and the Use of Personal Hearing Protection in Underground Coal Mines." Final Report by Pennsylvania State University, Bureau of Mines grant GO133026, December 1973, OFR 46-74, NTIS PB 235 867/AS.

5. "Personal Protection" by John Durkin. Proceedings of Bureau of Mines Technology Transfer Seminar on Noise Control, IC 8685, 1975, 108 pp.

6. "Noise Abatement of Pneumatic Rock Drill" by C. R. Summers and J. N. Murphy, Bureau of Mines RI 7998, 1974, 45 pp.

7. "Noise Control of Pneumatic Rock Drills" by Thomas G. Bobick. Proceedings of Bureau of Mines Technology Transfer Seminar on Noise Control, IC 8686, 1975, 108 pp.

8. "Mufflers and Jackets for Pneumatic Drills" by R. E. Manning. Proceedings of Bureau of Mines Technology Transfer Seminar on Noise Control, IC 8686, 1975, 108 pp.

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[3]OFR - Bureau of Mines Open File Report. Reports available for inspection during working hours at Bureau of Mines libraries in Pittsburgh, Pa., Twin Cities, Minn., Denver, Colo., Spokane, Wash., and Morgantown, W. Va. and at the Central Library, U.S. Dept. of the Interior, Washington, D.C., but may not be removed.

[4]NTIS - National Technical Information Service, U.S. Department of Commerce, Springfield, Va. 22161. Microfiche and paper copies are available and should be ordered by the numbers given.

9. "Muffler for Pneumatic Drills." Final Report by U. S. Steel Engineers and Consultants, Bureau of Mines contract HO220048, November 1972, OFR 28-73, NTIS PB 220-372.

10. "Noise Control on a Loading Machine" by Charles R. Summers. Proceedings of Bureau of Mines Technology Transfer Seminar on Noise Control, IC 8686, 1975, 108 pp.

11. "Noise Control of Diesel-Powered Mining Equpment" by Bolt, Beranek and Newman. Final Report Bureau of Mines contract HO346046, 1975. Report to be available shortly.

12. "Noise Control in Cleaning Plants" by W. N. Patterson et al. Proceedings of Bureau of Mines Technology Transfer Seminar on Noise Control, IC 8686, 1975, 108 pp.

13. "Coal Cleaning Plant Noise and Its Control." Final Report by Bolt, Beranek and Newman. Bureau of Mines contract HO133027, 1974, OFR 44-74, NTIS PB 235 852/AS.

14. "New Developments in Respirable Dust Control" by W. G. Courtney. To be published in the Proceedings of the NCA/BCR Coal Conference and Exposition, October 1975.

15. "The State of the Art in Continuous Mining Machine Bit Technology." Final Report by Bituminous Coal Research, Bureau of Mines contract HO220061, June 1973, OFR 71-73, NTIS PB 225 633/7AS.

16. "Water Through the Drum, 120M Jeffrey Heliminer." Final Report by Jeffrey Mining Machinery Company, Bureau of Mines contract HO232060, August, 1974, OFR 53-74, NTIS PB 236 584/AS.

17. "Effectiveness of Respirable Dust Control by Water Through the Drum on an 11CM Joy Continuous Miner." Final Report by Bituminous Coal Research, Bureau of Mines contract HO232061, OFR 54-74, NTIS PB 236 652/AS.

18. "Foam Suppression of Respirable Coal Dust." Final Report by Monsanto Research Corporation, Bureau of Mines contract HO100179, November 1971. OFR 10-71, NTIS PB 204 522.

19. "Dust Suppression in Coal Mines." Final Report by Deter Company Inc.. Bureau of Mines contract HO110929, July 1972, OFR 24-73.

20. "Portable Mine Dust Concentration Instrument." Final Report by Stamford Research Institute, Bureau of Mines contract HO1116888, June 1973, OFR 6-73, NTIS PB 215 150/4.

21. "Air Curtain Respiratory Protection Device." Final Report by Donaldson Company Inc., Bureau of Mines contract HO122087, September 1973, OFR 60-74, NTIS PB 236 090/AS.

22. "Coal Mine Combustion Products, Identification and Analysis." Final Report by Ultrasystems Inc., Bureau of Mines contract HO122009, July 1972, OFR 1-73, NTIS PB 214 124.

23. "Coal Mine Combustion Products, Identification and Analysis, II." Final Report by Ultrasystems Inc., Bureau of Mines contract HO122009, August 1973, OFR 8-74, NTIS PB 266 944/AS.

24. "Coal Mine Combustion Products, Neoprenes, Polyvinyl, Chloride Compositions, Urethane Foam, and Wood" by A. H. Hartstein and D. R. Forshey, Bureau of Mines RI 7977, 1974, 25 pp.

25. "Coal Mine Combustion Products: Identification and Analysis" by A. M. Hartstein and D. R. Forsehy, Bureau of Mines RI 7872, 1974, 12 pp.

26. "Gas Detection Instrumentation--What's New and What's to Come" by George H. Schnakenberg, Coal Age, 1975, 9 pp.

27. "Evaluation of Small, Color Changing Carbon Monoxide Dosimeters" by R. M. Ray, H. B. Carroll, and F. E. Armstrong, Bureau of Mines RI 8051, 1975, 21 pp.

28. "Accuracy and Precision of Several Portable Gas Detectors: Additional Studies, A Supplement to RI-7811" by H. B. Carroll, Jr. and F. E. Armstrong, Bureau of Mines RI 8010, 1975, 34 pp.

29. "Accuracy and Precision of Several Portable Gas Detectors" by H. B. Carroll and F. E. Armstrong, Bureau of Mines RI 7811, 1973, 42 pp.

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