TECHNICAL SESSION III

COAL DUST AND HEALTH AND SAFETY

"Respirable Dust Research"

by

John A. Breslin[1]

INTRODUCTION

The Respirable Dust Research Program of the Bureau of Mines originated with the Federal Coal Mine Health and Safety Act of 1969. This act established a standard for respirable dust, which is now 2.0 mg/m^3 for the average concentration of respirable dust to which coal miners may be exposed. The act also authorized research "to develop new or improved means and methods of reducing concentrations of respirable dust in the mine atmosphere of active workings of the coal mine." This research is being done by the Bureau of Mines, and some of the results of this work are presented here.

The objective of the Bureau's Respirable Dust Research Program is to develop new and improved technology to protect miners against respirable dust. The Bureau's mission concerns only the control and measurement of coal mine dust. We do not do any medical studies since these are the responsibility of NIOSH. MSHA is responsible for the enforcement of the dust standards in mines. However, the Bureau does conduct research to improve the methods for dust measurement in mines to assist MSHA in the enforcement of respirable dust standards.

About 30 percent of the Bureau's dust research is done through inhouse research projects; the rest is done through research and development contracts and grants. The inhouse research and monitoring of the outside contracts are done at the Pittsburgh Mining and Safety Research Center and Twin Cities Mining Research Center. The work at Twin Cities is primarily concerned with minimizing the formation of airborne dust by the optimization of mining machine cutting parameters or by the use of

[1]Staff Engineer, Office of Assistant Director—Mining, Bureau of Mines, U. S. Department of the Interior, Washington, D. C.

wet-head mining machines. The rest of the research on dust measurement and control is either done at or monitored by the Pittsburgh facility.

Five main research areas will be discussed: (1) measurement, (2) optimization of machine cutting parameters, (3) control by face ventilation and dust collectors (4) dust control using water, and (5) personal protection.

DUST MEASUREMENT

One purpose of the Bureau's dust measurement research is to assist MSHA by developing instruments and methods to measure mine dust concentrations for enforcement of standards. The other purpose is to improve the instrumentation used for the evaluation of dust control techniques.

Efforts are underway to develop an improved personal dust sampler. Contracts with Bendix and MSA for the development of tamper-proof filter cassettes are nearly completed. The new cassettes are designed to make it more difficult to either accidentally or deliberately tamper with the dust samples. They include one way flow valves and screens to prevent dust from being shaken loose from the filters, and they are constructed so that it is impossible to open and close a cassette without it being detected. Another contract with Bendix for more reliable rugged dust sampler pumps is also nearing completion. Ten prototype pumps have been delivered to the Bureau. The new pump will automatically control the air flow rate and will indicate if the flow was interrupted during a shift.

Area sampling where an area rather than a man is sampled is attractive since it would relieve the miners of the burden of wearing the dust sampler and might allow the use of more rugged and reliable, but possibly larger, dust-measuring instruments. Eastern Associated Coal Corporation, under a Bureau contract, has demonstrated that reasonably good relationships can be obtained between dust concentrations measured by samplers worn by miners and concentrations measured by samplers located at fixed points on mining machines. The concept of fixed-point sampling thus appears to be feasible. MSA Research Corporation is working on a contract to determine optimum locations for area sampling outby the face. This study is collecting data to help implement new regulations proposed by MSHA for use of area sampling to replace most of the samples that are now being taken for other than "high risk" occupations.

A long-range program has been initiated for development of a continuous recording respirable dust monitor that could be mounted on coal mining machines. This device could be used for enforcement purposes and also to give mine personnel an immediate indication when dust levels are excessive. This machine-mounted dust monitor will collect the respirable dust on a filter and will determine the mass of the collected dust using a beta-absorption technique. A prototype version of the collector-detector assembly

part of the monitor has been fabricated and satisfactorily tested. The system is designed to take 30-minute samples onto a spot on a filter tape and print the average respirable dust concentration for that time. The feasibility of using devices based on light scattered from dust particles as machine-mounted dust monitors is also being investigated in cooperation with MSHA.

Instruments are also needed that will allow engineers to quickly evaluate the effectiveness of dust control methods. GCA Corporation has developed a prototype portable light-scattering dust monitor for the Bureau. It is a photometer dust monitor using a pulsed laser diode light source. The instrument gives a continuous digital readout of dust concentrations over a range 0.01 to 100 mg/m^3. It weighs less than 9 pounds and should be very useful to engineers in coal mines.

OPTIMIZATION OF MACHINE CUTTING PARAMETERS

The Bureau's Twin Cities Mining Research Center is conducting research to reduce dust formation by optimization of mining machine cutting parameters. The machine parameters being investigated include bit type, sharpness, spacing, speed, depth of cut, and angle of cut. One phase of this program involves laboratory testing with single bits cutting coal using a linear cutting apparatus. The laboratory studies have shown that the formation of airborne respirable dust is greatly reduced as the depth of cut with the bit increases. These studies are also providing information on the dust formed by different types of cutting bits.

A primary component of the Bureau's research program to control dust in coal mines is the development and testing of deeper cutting mining machines. Under a recently completed cooperative experimental program, information has been obtained on the effects of depth of cutting and rotational speed differences on production, respirable dust levels, machine maintenance, and bit wear while operating a continuous mining machine in a production mode. Production tests were conducted at the cooperator's Joanne coal mine near Rachel, West Virginia. The mining plan allowed comparison of shallow cutting to deep cutting for the same production rates.

Dust measurement from these tests indicate that compared with shallow cutting at 51 rpm, deep cutting at 18 rpm reduced respirable dust by 73 percent in the air return and 63 percent at the miner operator location. Coal production in the low-speed, deep-cutting mode was the same as for the shallow-cutting operation. Thus it has been demonstrated that it is possible to mine coal at slow rational speeds with deep depth of cut, resulting in significant reductions in respirable dust with no loss in production.

CONTROL BY FACE VENTILATION AND DUST COLLECTORS

Face ventilation is the primary means being used to control dust in coal mines. Maintaining line brattice or tubing within 10 feet of the face can greatly reduce exposure of face workers to dust, particularly if an exhausting system of face ventilation is used. However, it is often difficult to maintain brattice and tubing within 10 feet of the face, and there are many complaints that this requirement leads to reduced coal production. Extensible face ventilation systems have been developed inhouse and through a contract with Foster-Miller Associates. None of the devices tested to date have been found practical for long term use in coal mines. However, further work in this area is planned by the Bureau.

The Bureau of Mines has developed or assisted in the development of several types of small, high-dust-collection-efficiency scrubbers that are suitable for mounting on mining machines. Extensive laboratory tests have determined the efficiency and performance characteristics of both the Bureau-developed and other commercially available scrubbers. Underground testing and laboratory modeling are providing additional guidelines for location of air inlets and air volume requirements for various types of mining machines.

A small 2,000-cubic-foot-per-minute flooded-bed dust collector has been developed in association with the DuPont Company. The scrubber consists of a 6-horsepower vaneaxial fan, a 1/4-inch-thick bed of 0.0035-inch-diameter stainless steel wire, water sprays, duct transition, and a high-velocity, blade-type water droplet eliminator. The collector is nominally 6 feet long with a 16 by 16 inch cross section. In the laboratory, the system has a respirable dust collection efficiency of 95 percent and the effluent is essentially free of water drops. From results of underground tests the Peabody Coal Company reports that this type of scrubber could effectively control dust on a working section with blowing ventilation. A 90 percent reduction in dust has been measured with a flooded-bed dust collector on a continuous miner in a blowing face ventilation system.

Flooded-bed scrubbers have been exchanged with the British National Coal Board for independent evaluations. British tests of the Bureau-designed scrubber showed it to have respirable dust collection efficiency of 94 to 98 percent. The British results confirmed results of earlier Bureau testing on the same scrubber and show that the testing procedures used in both countries are equivalent. Bureau tests of the British flooded-bed scrubber showed it to have dust collection-efficiency between 91 and 96 percent.

The Bureau has been supporting work, mainly through contracts, to install and test dust collectors on a variety of mining machines. An Eickhoff 340L double-drum longwall shearer was retrofitted with a dust collector by Donaldson Company under a Bureau contract. The bottom of the undercarriage frame was enclosed to form an air flow duct, and air intakes were provided along the undercarriage and behind each cutting drum.

The dust collector, installed at the tailgate end, consisted of water sprays, a minicyclone panel, and a 5,000-cubic-foot-per-minute exhaust fan. In underground tests at Eastern Associated Coal's Keystone No. 1 mine, the dust collection system reduced respirable dust by more than 60 percent along the face, in close agreement with values obtained in laboratory-scale experiments. Retrofit of a dust collector to a mining machine is always a difficult problem. A new contract is about to be awarded that calls for the development of a dust collector to be built into a new shearer rather than just added on.

DUST CONTROL USING WATER

Water can be used in a number of different methods to control dust in coal mines. Some of the methods that have been studied by the Bureau include (1) improved water spray systems, (2) nonclogging water filtration systems, (3) wet heads, (4) water infusion, (5) fine mists and steam, (6) foam, and (7) wetting agents and chemical binders.

The Bureau has been conducting both laboratory and field tests to determine the optimum types and locations of spray nozzles on continuous miners. The tests have shown that the nozzles located under the cutting boom of the continuous miner are generally more effective for dust suppression than those on the top and sides of the cutting boom. Water sprays generally can suppress up to 50 percent of the dust generated at the face if the spray system is properly designed.

Clogging of water spray nozzles is a common problem in coal mines. An improved water filtration system to reduce nozzle clogging was developed for the Bureau by Eastern Associated Coal Corporation. The system consists of a Y-shaped strainer to remove the larger particles, a hydrocyclone which removes most of the remaining particles, and a final filter. With minimal maintenance the system can virtually eliminate clogging of spray nozzles. The components are commercially available and can be purchased and installed for less than $1,000.

"Wet head" is a term used when water is supplied to the rotating cutting head of mining machines. The Bureau has sponsored research on wet heads for drum-type continuous miners, longwall shearers, and low-coal auger continuous miners. The most recent project involved development of a wet-head system for the Jeffrey 100L auger machine. Field tests showed that wet-head operation on this machine could reduce respirable dust by about 50 percent as compared to the conventional spray system. Jeffrey has developed and successfully demonstrated a wet-head system for the 100L machine. The cost of a wet head retrofit for this machine is about $7,000.

Another dust control technique being studied by the Bureau is water infusion. This technique requires that holes, usually over 100 feet long, be drilled into the coalbed prior to mining. Water is then pumped into the coal. This prewetting of the coal helps prevent dust from becoming airborne

during cutting and it also helps to reduce methane concentrations in the face area. In one test on a longwall face a dust reduction of 80 percent was achieved. However, the effectiveness of water infusion depends on the permeability of the coalbed and the moisture already in the coal. Thus infusion will be an effective control method in some mines, but not all.

PERSONAL PROTECTION

The primary emphasis of the Bureau's research is on control of dust in the mine environment since that is what the law requires. However, we have done some work on devices for personal protection of miners to reduce their exposure in areas where dust levels are high.

Donaldson Company has developed for the Bureau a canopy-mounted air curtain system for protection of mining machine operators against respirable dust. Mine air is drawn by a centrifugal blower through a filter which removes respirable dust. The clean filtered air is passed through a flexible duct to a manifold on the machine canopy and then flows down around the operator's head. Field tests have shown that this system can reduce the miner's exposure to respirable dust by up to 75 percent. The advantage of this system over most other personal protection devices is that it is not worn or connected to the operator and thus is not uncomfortable or restrictive. The cost of this system installed on a mining machine is about $1,500. More than 50 of the canopy air curtains have now been installed in mines.

CONCLUSION

Although coal mine dust levels have been greatly reduced since 1969, there are still improvements that can be made in the methods to control dust in mines. Some types of mining operations, such as longwalls, still are very difficult to bring into compliance with the dust standard. In some cases dust control methods have an adverse effect on coal production. Also very few people are completely satisfied with the methods now being used to measure respirable dust. The Bureau's research program is aimed at developing the technology to help solve some of these problems. We have had some successes, and some efforts have had negative results. Overall, we believe that real improvements are being made in the technology to protect miners against respirable dust.

QUESTION/ANSWER PERIOD

Question:

Can you tell us a little about the _____(not audible).

Answer:

That was an instrument that was developed by the GCA Corporation. It essentially works on the same principle as the SRI instrument which you might have heard of. The advantage of this instrument is that it uses a pulsed laser diode. The electronics are much more stable than the SRI which Bureau personnel have been using in the past. This instrument looks very stable. It has been tested quite extensively, at least the prototype has, and it looks good. It's not available right now commercially. We only received a prototype about two months ago. I would suspect that within a year you might see this available. It could be a very useful instrument for the dust control engineers. As far as correlation with gravimetric measurements, this is a light scattering instrument. All light scattering instruments respond to the surface area of the particles rather than the mass. The response of this instrument is going to be dependent upon the size distribution, therefore, you are never going to really have an exact correlation with gravimetric measurement. It's useful for the dust control engineer, but you can't believe the number absolutely in terms of gravimetric concentrations.

Question:

What can we do about the clogging of these venturi sprays?

Answer:

I could suggest the non-clogging spray system if you're not using that. If the screens are being clogged on the nozzle, you have particulates in the water system and you can make an improvement in the filtration system on the mining machine.

Question:

What was the pressure for the most successful water infusion test?

Answer:

I don't know exactly what the pressure was. The tests were conducted in the Pocahontas No. 3 Seam which is, incidentally I think, the only coal seam where water infusion is being used as a dust control method right now.

Question:

Can the dust regulations be met by adjusting the cutting parameters only?

Answer:

I think the answer has to be "no." You can't just concentrate on any one dust control technique. I think that any mine is going to have to be well ventilated. As I pointed out with Big Bertha, you can actually get 70 percent reductions in dust, but if you're five times over the limit, you're still not going to be in compliance. You have to pay attention to everything. But adjusting the cutting parameters is certainly an important thing to do, particularly with longwall shearers where ventilation alone is not going to be the answer.

Question:

Not audible.

Answer:

I couldn't say we've conducted any extensive field testing at all. We have been doing some laboratory testing of wetting agents. In the laboratory we are testing a large number of wetting agents on a large number of coals which we have gotten from various districts with the assistance of MSHA. The results show that it can be significant which wetting agent you are using on which coal. There's no one wetting agent that is working everywhere. These are laboratory tests, though. As far as underground tests are concerned, there's been reports from a number of sources of people who have used wetting agents for dust control. Some people think they're great. I think more people think they're not doing anything at all. I think the answer may be that it might depend on the individual application. In some cases wetting agents are needed. In other cases where the water is already wetting the coal, adding a wetting agent isn't going to do any good.

Question:

Not audible.

Answer:

The dust standard in the 1969 Act was that the average dust concentration to which a miner is exposed should not exceed 2 milligrams per cubic meter over an eight-hour shift. That's the standard which MSHA is enforcing right now.

Question:

Has there been any testing on the use of steam for dust control on longwalls?

Answer:

I don't think there's been any field testing on the use of steam on longwalls, at least not by the Bureau. The Bureau did conduct some tests on the effectiveness of steam and water-spray combinations. The result of the laboratory tests was that there was some, but very slight advantage to the use of steam; it wouldn't have justified the logistic difficulties of having to put a steam generator in a coal mine. There have been some tests on steam on a road header in Britain about two or three years ago. I know that got a lot of publicity over here. Talking to some British dust control engineers, I don't think they feel that it was actually a fair test--that steam is not a practical control technique for road headers either. I don't think there's any case where we'd really recommend it.

Question:

Is it practical to put a scrubber on a continuous miner for a forty-inch seam?

Answer:

I think the answer is: "Today probably not, hopefully in the future, maybe." The scrubbers are just too large for that height of coal seam.

SEPTEMBER 6, 7 AND 8, 1978
BLACKSBURG, VIRGINIA

NINTH ANNUAL INSTITUTE ON COAL MINING HEALTH SAFETY & RESEARCH

PROCEEDINGS 1978

CENTER FOR CONTINUING EDUCATION
VIRGINIA POLYTECHNIC INSTITUTE &
STATE UNIVERSITY
BLACKSBURG, VIRGINIA

NINTH ANNUAL INSTITUTE ON COAL MINING HEALTH SAFETY & RESEARCH

PARTICIPANTS & SPONCERS

U.S. DEPARTMENT OF LABOR

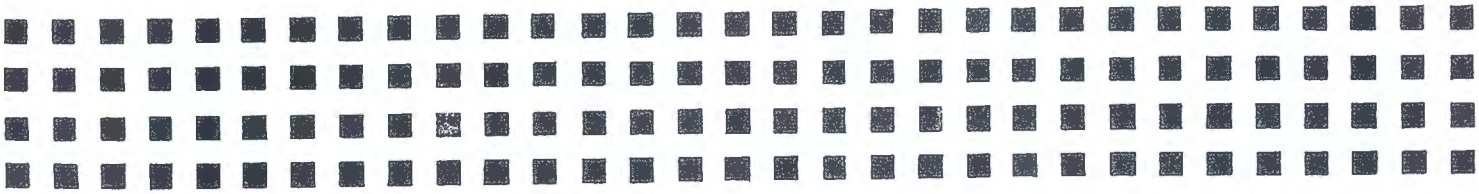
MINE SAFETY & HEALTH ADMINISTRATION

U.S. DEPARTMENT OF THE INTERIOR

BUREAU OF MINES

DEPARTMENT OF MINING & MINERALS ENGINEERING

VIRGINIA POLYTECHNIC INSTITUTE & STATE UNIVERSITY



PROCEEDINGS EDITED BY:

DR. WILLIAM E. FOREMAN
ASSOCIATE PROFESSOR

DEPARTMENT OF MINING & MINERALS ENGINEERING

VIRGINIA POLYTECHNIC INSTITUTE & STATE UNIVERSITY

BLACKSBURG, VIRGINIA