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TWENTIETH ANNUAL INSTITUTE ON COAL MINING HEALTH, SAFETY AND RESEARCH

Edited by

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BUREAU OF MINES
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TECHNICAL PROGRAM

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Thanks and appreciation go to the Planning and Advisory Committee for its effort and support throughout the development of the conference program. In addition, specific acknowledgement is made to Mr. William H. Sutherland and Dr. David R. Forshey, my conference co-chairmen, for their special assistance and advice during the planning of the conference and for their contributions in editing the *Proceedings*. Finally, the assistance received from Johanna Sherwood Jones in the editing of this volume, and from Mary Behnke, Lisa Blankenship, and Peggy Douthat in its preparation, is greatly appreciated.

Michael Karmis
Conference Co-Chairman
Blacksburg, Virginia
August 29, 30 & 31, 1989

INTRODUCTION

This *Proceedings* contains the presentations made during the program of the Twentieth Annual Institute on Coal Mining Health, Safety and Research held at the Donaldson Brown Center for Continuing Education, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, on August 29, 30 and 31, 1989.

The Twentieth Annual Institute on Coal Mining Health, Safety and Research was the latest in a series of conferences held at Virginia Polytechnic Institute and State University and cosponsored by the Mine Safety and Health Administration, United States Department of Labor and the Bureau of Mines, United States Department of the Interior.

The Institute provides an information forum for coal operators, mine managers, superintendents, safety directors, engineers, inspectors, researchers, teachers, and state agency officials, and others with a responsible interest in the important field of coal mining health, safety and research.

In particular, the Institute is designed to help mining operating personnel gain a broader knowledge and understanding of the various aspects of coal mining health and safety, and to present them with methods of control and solutions developed through research.

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WELCOMING ADDRESS

Paul E. Torgersen, Dean
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As you may know, this is the 20th anniversary of the Coal Mining Health, Safety and Research Institute. The first was offered in the late summer of 1970.

This institute - and my opportunity to offer a welcome - has had a special meaning for me over the years. I was appointed Dean of the College of Engineering in the late spring of 1970. Thus, I began my first full academic year - the 1970-71 academic year - by welcoming this conference. I have done so every year with one exception, that being a year when I spent the late summer and early fall in Australia...and Dick Lucas would not pay my return air fare solely so that I could welcome the institute!

This year will be my last year as Dean. At the end of this year I will have served 20 years as Dean - and that is long enough. I am the senior engineering dean in the country...few survive ten years, much less 20. I will be returning to teaching full-time next summer, so this, my last opportunity to welcome you, has a special meaning.

Over the years I have attempted to interject in my welcoming remarks a few descriptions of the College of Engineering. I am pleased to be able to report that those descriptions have been more and more positive as the years have progressed. In 1970 we were a very good college of engineering, largely committed to undergraduate education. Today, we are an exceptionally strong college and universally recognized as one of the premier colleges in the country. At the undergraduate level, we have become very selective in admissions simply because the reputation of the college has led to an increasing number of applications. Today we receive some 5,000 applications for approximately 1,150 freshman positions. We were the first publicly supported college in the country to require personal computers of all entering freshmen. Our undergraduate laboratories, and the faculty committed to undergraduate instruction, are at least as good as the exceptional student body which we enroll each year. We have changed, however, over the past two decades. We are now also committed to graduate education, research and scholarship. We will do in excess of 20 million dollars of research, including some exciting work in coal mining, and we did almost no research two decades ago. We will graduate between 300 and 400 master's candidates and between 80 and 90 Ph.D's each year. We did very little of this 20 years ago. Indeed, in a recent survey reported in U. S. News and World Report, engineering deans across the country acknowledged our inclusion as one of the top twenty graduate colleges in the country, and only one of two in the whole southeast.

In my welcoming remarks over the past few years, I have, on occasion, attempted to interject some humor into my welcoming remarks. I would have liked to have been able to do something humorous in this, my last, welcome. Like many of you in the audience, though, I am deeply troubled by the events in Southwest Virginia - the coal strike and all of its ramifications. I don't believe that humor is in order. I would not presume to pass judgement on the respective positions taken by the United Mine Workers and the Pittston Company, but I am terribly saddened by what I read in the newspapers and I know that there are many on both sides of the argument who are suffering through this dreadful strike. I would close by simply stating what is in my heart and I know in all of yours...I most sincerely hope and pray that the strike in Southwest Virginia will be resolved in the very near future.

This conference must go on. I hope that it is as successful as it has been in the past, and as Dean of the College of Engineering, I welcome you to Blacksburg and to our campus yet this one more time.

KEYNOTE ADDRESSES

Wolfgang Obst, Head of Division "Safety and Health in the Extractive and Steel Industries," Commission of the European Communities, Luxembourg

"Activities of the Commission of the European Communities in the Field of Safety and Health in the Extractive Industries, With Special Reference to Coal Mining"

T S Ary, Director, Bureau of Mines, United States Department of the Interior, Washington, D.C.

"Keynote Address"

Roy L. Bernard, Deputy Assistant Secretary of Labor for Mine Safety and Health, Mine Safety and Health Administration, Washington, DC

"Address"

Joseph Main, Administrator, Department of Occupational Health and Safety, United Mine Workers of America, Washington, DC

"Milestones of the Twenty Years of the Coal Mine Health and Safety Act"

Activities of the Commission of the European Communities in the field of Safety and Health in the Extractive Industries, with special reference to Coal Mining

Wolfgang Obst

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Directorate-General Employment,
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INTRODUCTION

General

Close cooperation in safety and health protection of the workers occupied in the coal mining industry of the European Communities was initiated by the Treaty of Paris, signed in 1951, which established the European Coal and Steel Community (ECSC)

ECSC Research

Social research began in 1955. It includes programmes on safety, health, hygiene, occupational medicine and ergonomics or, succintly, on the protection of the workers in the coal mining and steel industries against occupational risks. These research programmes, managed by Directorate-General for "Social Affairs," were subsidized from the ECSC budget by around 300 million ecus until the end of 1988.

Technical research has furthermore been carried out over the same period, involving total ECSC grants of around 320 million ecus for the coal sector. This research also had an influence on the evolution of safety in mines, for instance research on ventilation, firedamp emission and drainage, roof control and support.

The Safety and Health Commission for the Mining and Other Extractive Industries

Creation Another initiative was started one year later, as a consequence of a serious fire in the Bois de Cazier mine at Marcinelle in Belgium where 264 workers were killed.
The Council of Ministers of the European Coal and Steel Community reacted immediately and summoned a tripartite conference to identify those matters where safety should be improved. Following this conference, the Mines Safety Commission was established in 1957 as a permanent body at Community level where representatives of governments, workers and employers organisations worked together.

Later on, in 1965, its competence was extended to health protection and in 1974 to all extractive industries.

Tasks Pursuant to the terms of reference decided by the Council of Ministers, the most important task of the Safety and Health Commission was to submit proposals to the governments of the Member States to improve safety and health protection.

This action was intended to influence national legislation and rules. On the other hand, the Safety and Health Commission was also involved in the preparation, coordination and evaluation of ECSC research projects.

Summary Many ECSC research projects were carried out over this period of more than 30 years and many proposals to the governments of the Member States were prepared by the Safety and Health Commission together with reports, codes of good practice, etc. But what was the outcome of all this work?

EVOLUTION OF ACCIDENTS AND PREVENTION

General

We have community statistics to assess the results of research work and of work to prepare legislation and rules. This work was done at both the national and international levels.The Community statistics scheme for accidents in coal mining underground was developed in 1957 and was operational from 1958 until the end of 1985. Important changes in the accident statistics scheme introduced in one of the major coal producing Member States in 1986 necessitate a revision of the Community scheme which has not yet been completed.

The figures compiled in Table I show,for the period from 1958 to 1985,a marked decrease in the rate of accidents in total, including all accidents resulting in incapacity involving an absence from work of more than 3 days. The same applies to the rate of fatal accidents and the rate of accidents resulting in incapacity involving an absence from work of 4 to 20 days and of 21 to 56 days. However, the decrease in the rate of accidents involving an absence from work of more than 56 days or those termed "serious accidents" is not as marked as for the other accident rates. All of these accident rates are related to 1 million hours worked.

It should be mentioned that the scope of these statistics, as far as figures for the European Community as a whole were concerned, changed over these 30 years. In 1973 the United Kingdom joined the Community, in 1985 Portugal and Spain.

On the other hand the evolution of some figures, in particular the number of workers employed and production,did not follow the same trend in various Member States.From 1974 up to 1985, however, these statistics were mainly determined by the two most important coal producing Member States, the United Kingdom and the Federal Republic of Germany. This fact assures a high level of continuity.

Evolution of Specific Accident Rates - Preventive Action

The Community accident statistics scheme also allows examination of details, for example the evolution of accidents caused by firedamp and coal dust explosions. Last year we made a statistical study of this subject which gave the clear results represented in Table II.

Table I: Some statistical figures referring to coal mining underground in the European Communities

Period		1958	1971	1985	1988
1.	Number of workers employed (in thousands)	638	244	315	230
2.	Production of coal (mio tons)	252	165	201	215
3.	Productivity (output in kg per man and hour worked underground)	200	398	474	579
4.	Accident rates per 1 million hours worked				
4.1	Total (incapacity more than 3 days)	-	180	94.5	
4.2	Incapacity 4 - 20 days	-	114	56.15	
4.3	Incapacity 21 - 56 days	-	51	27.30	
4.4	Incapacity more than 56 days	13.55	15.09	10.8	
4.5	Fatal accidents	0.61	0.44	0.26	
	(Total figures)	770	182	107	

Table II

Explosions of firedamp and/or dust in the coal mining industries of the European Community

Period	Number of explosions		Number of fatalities caused by explosions		Number of persons employed under-ground (average)	Rate of fatalities per 100.000 persons employed under ground (average)	Output of coal in mio tons (average)	Number of fatalities per explosion (average)	Number of explosions per year and per 100.000 persons employed underground (average)
	Tot.	Aver./ year	Tot.	Aver./ year					
1958 - 1964	8	1,14	423	60	325.000	18,4	237	52,9	0,35
1965 - 1974	9	0,9	146	14 6	311.000	4,7	215	16,2	0,29
1975 - 1985	9	0,8	71	6,4	331.000	1,95	230	7,9	0,24

This table shows that the number of explosions per year related to 100.000 men employed was slightly decreasing from 1958 to 1985 but there was a marked decline in the number of fatalities per explosion and, as a result, in the average number of fatalities caused by explosions per year. This also shows that the measures to limit the effects and the extension of explosions were rather successful, whereas the measures to avoid explosions were at the end of this period not much more effective than at the beginning. Work must therefore be continued in order to reduce the number of explosions by preventive action and to confine the consequences of explosions to an even more limited area. Means of meeting the second aim are explosion-arresting devices such as triggered explosion barriers. Good progress has been made in developing triggered systems which can be used in mining practice and further efforts are being made, in particular with a view to reducing costs and facilitating maintenance but also with a view to increasing the mobility of these systems and, in general, their range of application.

Where other means cannot be used effectively to suppress explosions those devices can avoid the propagation of explosions, in particular

- near the front of headings, with the ultimate aim of protecting the whole crew, including the conductor of the heading machine;
- near longwall face - roadway junctions, with the aim of stopping an explosion which started inside a longwall face as near as possible to its entry.

However, recent experience has confirmed that non-triggered explosion barriers can be very effective and reliable means of suppressing explosings and of limiting their effects and extension. All explosions which have occurred since 1982 in Community coal mines were stopped by non-triggered water trough barriers.

Work to improve the prevention of explosions was done during these 30 years, but some events had a major impact on this work.

One was the firedamp and coaldust explosion at the Luisenthal mine in the Saar coalfield in 1962, where 299 men were killed.

Following this accident, water trough explosion barriers and neutralization of coal dust by hygroscopic salts were introduced in West German coal mines.

The High Authority of the ECSC started a competition to develop more efficient equipment to monitor methane and oxygen and to promote the development of more effective self rescuers. The Safety and Health Commission decided to reexamine all aspects of coaldust explosions and prevention methods.

In 1974 another explosion causing the loss of many lives occurred at the Liévin mine in the North-Pas-de-Calais coalfield in France, where 42 men were killed. Following this accident, water trough explosion barriers, neutralization of coal dust by stone dusting and in certain circumstances by hygroscopic salts were introduced in French coal mines.

The last explosion in a hard coal mine in the European Community where a larger number of men were killed occurred in 1985 at the Simon mine in the Lorraine coalfield, Twenty-two men were killed by a firedamp/coaldust explosion and 269 other persons affected to varying degrees by explosion fumes.

Following this accident, the European Parliament invited the Commission of the European Communities and the Safety and Health Commission for the Extractive Industries to make proposals to improve safety conditions in coal mining in the Community and to shed light on the causes of this disaster.

The French inspectorate prepared amended regulations and the Charbonnages de France decided to abandon flame lamps and to introduce a new type of portable automatic methane monitoring instrument and, in the Lorraine coalfield, light oxygen self-rescuers. Furthermore, a new series of trials with triggered explosion barriers was started in headings equipped with roadheaders.

The Secretariat of the Safety and Health Commission made a statistical study on group accidents (1) between 1975 and 1985 in coal mines of the Community.

The study showed that, of the thirteen group accidents, which occurred during this period, nine were caused by firedamp explosions, frequently followed by coal dust explosions, and seven of these nine explosions were connected with auxiliary ventilation. Most occurred after prolonged stopping or disruption of the auxiliary ventilation.

The Safety and Health Commission decided to reexamine, with special reference to auxiliary ventilated workings, the following subjects

- how to improve the continuity and monitoring of auxiliary ventilation
- how to reduce the explosion risk and the effects of ignitions of firedamp and explosions;
- how to improve fire-prevention, fire-fighting, escape and rescue in the event of explosions and fires
- how to improve the training of personnel for the above purposes.

This work was done by 6 subcommittees and 5 committees involving about 100 persons over a period of more than two years. The Safety and Health Commission examined and adopted the final report in January 1989, which will be submitted to the European Parliament in autumn 1989.

The title of this report is "Measures to reduce the explosion and fire risk in auxiliary-ventilated mine workings and to improve the protection of personnel in the event of explosions and fires."

The report is structured as outlined in Table III.

Table III: Structure of the report to the European Parliament

General Introduction

Part 1:	Safety of auxiliary ventilation
Part 2:	Reduction of explosion risks
Part 3:	Improved fire prevention, fire-fighting, and protection of personnel in the event of explosions and fires
Part 4:	Human factors

It might be of interest to give some details of the proposals to the governments, which are the most important part of the report.

The safety of auxiliary ventilation should be improved by measures to reduce the numbers and duration of auxiliary ventilation stoppages and disruptions. The power supply must be designed to provide separately for the fans and for the electrical equipment inside the heading. Voluntary stoppages must be planned to minimize their duration. Suitable procedures must be laid down to ensure the safety of the workforce in the event of unforeseen stoppages of ventilation and for recommissioning. This applies particularly to the method of degassing.

In addition to the routine testing of the mine air using hand-held devices, monitoring of auxiliary-ventilated headings, in particular with respect to firedamp concentrations, should be carried out by automatic instruments which transmit, record and process the data obtained in order to assist mine management, trigger alarms and cut off the power supply if necessary.

It is clearly desirable for the greatest possible number of communications, signalling and monitoring devices to continue to operate when the firedamp concentration exceeds the statutory limit for the use of electricity.

Examples for measures to reduce the explosion risks have already been dealt with in this paper. Proposals to the governments on this subject to supplement other and still valid proposals submitted earlier to the governments concern:

- The containment of explosions by the use of non-triggered barriers of the wide-action type; the first trough should be at a maximum of 120 m from the face.

- The containment of incipient explosions by triggered barriers and other similar devices.

Much research and development work was done to eliminate ignition risks, e.g. by reducing the number and the consequences of frictional ignitions. Nevertheless, work should be continued to take account of technical progress.

The use of flame lamps was recently disputed again following the explosions at the Simon mine and the Moura mine. These lamps can now be replaced by modern electronic detection devices suitable for the detection of firedamp as well as oxygen deficiency.

Another important item is the neutralization of coal dust although the report does not treat this problem in detail. Experience showed that the efficiency of neutralization methods is difficult to ensure in mining practice.

New practical means to reduce still further the quantity of flammable dust liable to become airborne should be developed, for example means to remove dust deposited on the floor, the walls and the equipment.

The report to the European Parliament also includes proposals to the governments on improved fire prevention, fire-fighting and protection of personnel in the event of explosions and fires.

It might be of interest that one of the proposals of the Safety and Health Commission was the following: "...Mobile survival chambers equipped with oxygen self-rescuers are desirable at the head end of drivages with rubber-tyred diesel vehicles..." This is not a firm proposal but it shows our efforts to improve the protection of workers in those drivages and a tendency to use more extensively oxygen self-rescuers together with survival chambers.

Another proposal was that it must be possible to warn the personnel concerned, in the event of an explosion or a fire, without delay.

The last part of the proposals to governments concerns the human factors which include:

General principles, i.e.
- information and training;
- rules, working procedures, signals and signalling systems;
- communication and work organization.

Application of these principles, i.e.
- design and planning of workings
- conduct of operations
- conduct in the event of an incident or accident
- Personnel concerned

This was an example of the recent work of the Safety and Health Commission.

In June 1988 another violent and extended explosion occurred in a mine in the European Community. It was a dust explosion in a German lignite mine in the Land Hessen, where 52 men were killed. Six miners survived and were rescued three days after the explosion. The lignite dust of this mine was classified as not dangerous because of the high natural humidity. The use of dynamite type-explosives was authorized by the mines inspectorate many years ago.

First results of the enquiry showed that the natural humidity was reduced because of the extremely dry climate in May 1988 and the mine workings being at no great depth at about 100 m.

Following this accident, explosion barriers were introduced in the other underground lignite mine in the Land Hessen. Since a large proportion of the victims were killed by high CO-concentrations in the fumes, oxygen self-rescuers were introduced in the same mine.

As usual the final report of the enquiry, not yet available, will be carefully examined by the Safety and Health Commission and conclusions will be drawn.

Another example is falls of ground and rock accidents. The rate of fatal accidents fell from 0.25 in 1958 to 0.1 in 1985, and the rate of "serious accidents" decreased from 4.85 in 1958 to 2.0 in 1985.

The reason for this favourable evolution is the introduction of powered supports at winning faces.

The evolution of accident rates related to haulage and transport, to movement of personnel, to machinery, handling of tools and supports is not as positive as for accidents related to explosions and falls of ground and rock mentioned above.

Conclusions

Statistics show a marked decrease in accident rates over the period from 1958 to 1985, the last year for which comparable figures are available for the European Community. This evolution was certainly influenced by ECSC-research work and by the work of the Safety and Health Commission for the Extractive Industries.

HEALTH PROTECTION AND OCCUPATIONAL DISEASES

General

Now it might be of interest to have a look at health protection and the evolution of occupational diseases. ECSC social research programmes on industrial medicine and industrial hygiene in mines were started in 1955. The Safety and Health Commission began its work to improve health protection in 1965.

The results of efforts in this field cannot be assessed at European Community level, since there are no harmonized statistics. Harmonized legislation on these diseases is still awaited. However, national statistics are available for assessment of the evolution in some sectors.

Pneumoconiosis

A high proportion of the work in the field of health protection carried out at Community level was intended to reduce the risk to health associated with the exposure to fibrogenic mineral dust.

There was extensive research into respiratory diseases and at the same time research in to reducing the dust exposure and improving dust measurement methods.

The Safety and Health Commission prepared several recommendations, guidelines etc. on dust suppression and dust measurement. Recent proposals to the governments also deal with the pneumoconiosis risk. This document includes provisions for the monitoring of airborne dust and on limit values for respirable dust as well as a code of good practice to reduce exposure to dust. The intention of the Commission of the European Communities is to include these limit values in a directive.

Statistics on pneumoconiosis are available for the Federal Republic of Germany and the United Kingdom, the most important coal-producing Member States.

Table IV

Table IV shows the incidence rates of new cases of pneumoconiosis in the Ruhr and the Saar coal-mines for the period from 1957 to 1987. Table VI shows furthermore the evolution of new cases in absolute figures in the German mining industry. A long-term and continuous reduction can be observed. It might be also of interest that the average life expectancy for a miner affected by silicosis in Germany rose steadily from 58.2 years in 1957 to 77.2 years in 1986.

Table V

Table V gives the incidence rates of new cases of pneumoconiosis in the coal mining industry of the United Kingdom from 1965 to 1987. It shows, as for German coal mines, a continuing downward trend. Furthermore, for both Member States the age and the period of exposure when the disease is recorded for the first time is increasing and the progression of the illness is decreasing.

Several measures may have contributed to this positive development: technical measures to reduce dust emission, organizational measures to reduce dust exposure, measures to protect workers by insulation, for example by cabins, and by the use of protective equipment. Furthermore, improvement in medical supervision and in medical care has certainly played an important role.

Table IV
Incidence rates of new cases of pneumoconiosis diagnosed by Pneumoconiosis Panels 1957–1987 in the Ruhr and Saar coal-mines (Rates per 1000 men employed)

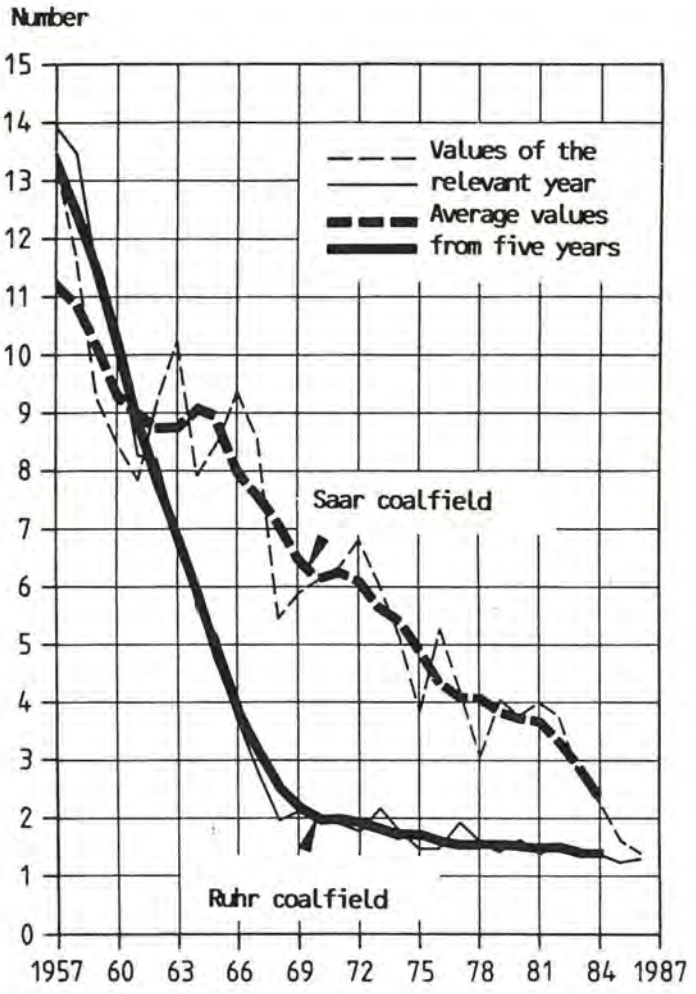


Table V: New Cases of Pneumoconiosis Diagnosed by Pneumoconiosis Panels 1965-87 for men still employed in coal mining (Rates per thousand men employed)

Exposure to noise

The reduction of exposure to noise at work was, in the last ten years, a major topic of the work at Community level. ECSC research on this subject was subsidized within the programmes on industrial hygiene in mines and on ergonomics. The Safety and Health Commission looked very carefully at this problem. A report on this subject based on studies carried out in the industry was published in 1983.

A draft Council Directive on the protection of workers from the risks related to exposure to noise was prepared by the Health and Safety Directorate in Luxembourg and adopted by the EC-Council on 12 May 1986 (1).

This directive, which also applies to underground mining, must be implemented by the Member States by 1 January 1990. The Council and the EC-Commission invited the Safety and Health Commission to draw up recommendations for the implementation of this directive in the extractive industries. The Safety and Health Commission decided to prepare a code of good practice for this purpose, limited to underground workings where special environmental and working conditions exist.

This document will be finalized by the end of 1989.

Statistics on new cases of damage to hearing are available for the German mining industry.

Table VI shows the evolution of new cases in absolute figures. The high number of new cases in the period from 1976 to 1981 was due to the fact that damage to hearing was first prescribed as an occupational disease in 1964 in the Federal Republic of Germany. The number of new cases per year fell rapidly from 1981.

Other Occupational Diseases and Health Hazards

Table VI shows that a few more important occupational diseases exist in the German mining industry, i.e. damage to the meniscus, still rather important but decreasing in numbers, diseases caused by pneumatic tools, and silicosis tuberculosis, also decreasing in absolute figures.

Other health problems to be considered are skin diseases and back pain.

Some other work done at Community level related to the following subjects:

- Research and studies were carried out on climatic conditions. The Safety and Health Commission published in 1966 a report and recommendations on climatic limits, based on the Basis Effective Temperature.

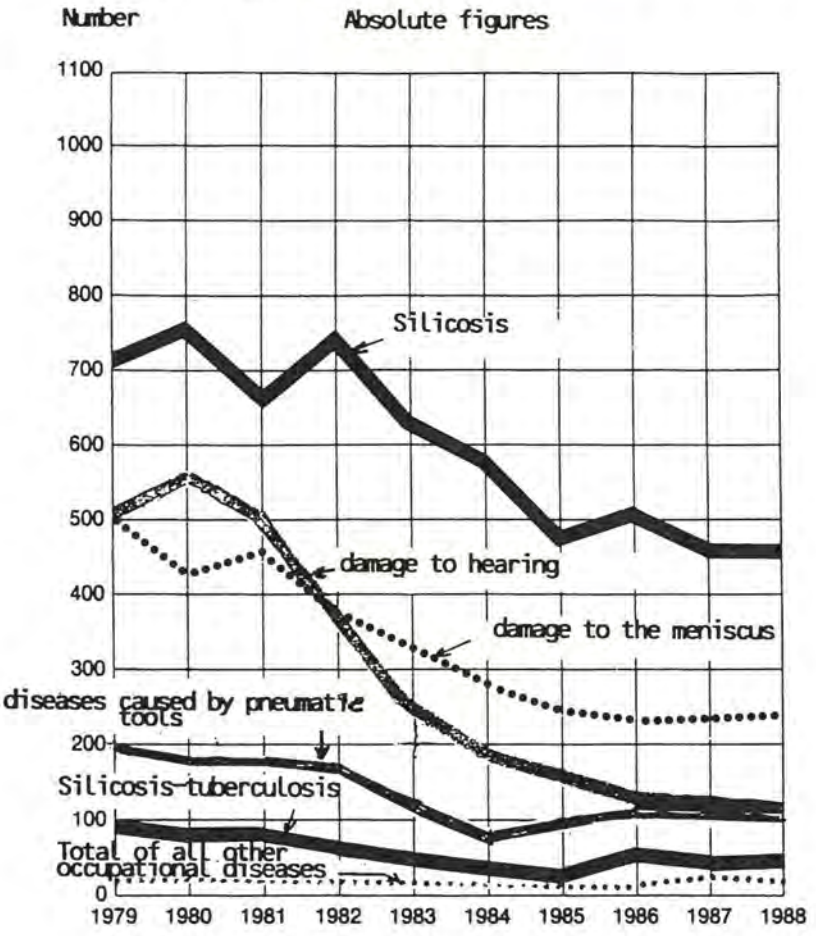
  Specific research is still continuing on work under adverse climatic conditions, for example work of rescue teams to seal off fires underground.

- Research and studies were also carried out on exposure to radon daughters. Samples have been taken in selected mines in various Member States.

Table VI

(1) Council Directive 86/188/EEC, Official Journal EC No L 137 of 12 May 1986, p. 28.

Table IV New cases of occupational diseases in the German mining industry



Conclusions

Statistics from the Federal Republic of Germany and from the United Kingdom indicate that the long-term efforts to reduce the pneumoconiosis risk in the mining industry resulted in a significant reduction of the number of new cases per year. This also applies to the rate per 1.000 workers employed during the period of the exposure. Due to the frequently severe consequences of this occupational disease measures to reduce dust exposure of workers, in particular dust suppression, remain, however, a high priority.

As far as damage to hearing is concerned, statistics were only available for the German mining industry where the number of new cases per year is steadily decreasing. The implementation of the Council Directive to reduce noise exposure at work from the beginning of next year onwards will certainly lead to further efforts.

OTHER ACTIVITIES AND FURTHER WORK

Non-Coal Mining Sectors

Much work was done at Community level in the non-coal mining sectors of the extractive industries. The EC Commission promoted over many years research in the iron ore mining sector. From 1974 when its terms of reference were extended, the Safety and Health Commission started work in the field of exploration and exploitation of petrol and natural gas and also in the field of underground non-coal mining. Later on, the activity was extended to the quarrying industries.

A number of proposals to the governments of the Member States and reports to improve safety and health were published concerning these sectors of the extractive industries.

Community Legislation

The aim of completing establishment of the internal market of the European Community by the end of 1992 sets the priorities for our present work and for work in the immediate future.

The EC-Commission has prepared a series of proposals to improve the health and safety of workers. The EC Council examined these proposals in cooperation with the European Parliament and after consultation with the Economic and Social Committee. A great proportion of these proposals has been finally adopted and implemented into the national law of the Member States.

For the workplaces in the extractive industries, draft proposals for three directives concerning the minimum safety and health requirements will be prepared by the Safety and Health Commission. These draft directives will cover the sector Underground Mines, the sector Opencast Mines and Quarries and the secor Petroleum and Natural Gas Extraction. The minimum health and safety requirements to be included in these directives will be based on principles and will not include technical details. Some of this work has already been started and we hope to complete the draft proposals by the end of June 1990.

However, it must not be forgotten that the management of ECSC research is an ongoing task.

CONCLUSIONS

It was a great honour for me to present some of the results of work done over a period of 30 years on health and safety in the coal mining of the European Community to this audience.

The decisions to create collaboration at Community level might have been milestones in health, safety and research in the sense of the title of this conference. Research managed and sponsored by the European Community, as well as efforts to improve safety and health protection of workers in all sectors of industry, are still positively influenced by the long experience in collaboration in the fields of coal and steel.

KEYNOTE ADDRESS - VPI CONFERENCE

T S Ary

Director

U. S. Department of the Interior

Bureau of Mines

It is a pleasure and a privilege to address this meeting on its 20th anniversary. Over that time these meetings have served as a forum for mine operators, mine inspectors, labor representatives, and researchers. The views expressed have been varied and often controversial, but the ultimate objective of everyone has been the same: to protect the health and safety of those who labor in the mines.

Many problems have been solved. Others have arisen as mechanized mining has increased, and mines have gone deeper to access reserves. Foreign competition threatens the U.S. mining industry. Forays into other types of energy have forced coal to fight for its position as a principle source of energy, but the future holds a promise of increased health, safety and production through new technologies that offer to reduce exposure to hazards and reduce the number of inefficient tasks.

A look at the contents of previous meetings clearly shows that the central theme has been constant--that the workforce is mining's most precious resource and a healthful and safe mine is a productive one.

Some of the problems that have confronted us are inherent to the mining industry: dust, noise, gases and roof falls. Others are associated with advances in mining technology: cutting machines, electrical equipment, and explosives. One by one, the challenges have been met by the people that these meetings bring together.

In 1973, at the 4th Annual Meeting, Robert G. Peluso, of what was then MESA, now MSHA, one of the original sponsors of these 20 gatherings, envisioned a mine equipped with a well-protected mining machine with water spray nozzles, a computer-like control console, ventilation inlets, and cutting bits designed to minimize dust, noise and spark ignition; enclosed conveying systems; and diesel engines with purified exhaust. He called this an "imaginative exercise." In 1989, you all know how much of this has become reality.

The proper utilization of human resources has a profound affect on the competitiveness of the American mining industry. American culture places a higher value on its skilled labor and demands greater safety and leisure time than that permitted by

industries in the emerging third world countries. To remain competitive without compromising these values, American industry must not only work harder, but smarter. In the mining industry, this means not only taking advantage of new technologies, but also improving the fit between the highly skilled miner and the new high technology tools. Human factors research is the appropriate means of improving this fit. Too often, American management treats the human and technological elements of production as if they were separate and independent and spends most of its resources improving technology, not knowing or believing they can improve the human element. A more comprehensive and valid system perspective is provided by a human factors analysis of the human-machine-environment interface.

The goal of human factors is overall system effectiveness, the two primary components of which are safety and productivity. While these two components are often considered to be mutually exclusive, several Bureau of Mines studies have shown that they are positively related. A well-run mine minimizes hazards as it streamlines production.

Following a decline in productivity during the 1970's which was reversed in the 1980's, the Bureau investigated MSHA's accident statistics to see whether the positive relationship between safety and productivity still existed (Figure 1).

It was found that the incidence rates for both fatal and lost-time accidents tended to be lower in years with the highest productivity: 1988, with the highest productivity, also had the lowest fatality rate; 1980, with the worst productivity, had the worst lost-time accident record.

High Productivity Mines: Another Bureau study[1] that evaluated 25 high-production continuous miner sections showed that all of these outstanding producers promoted good engineering practices and positive labor-management relations. Production from these continuous mining sections at these mines averaged 2 to 5 times the national average of 370 tons per production shift. Based on MSHA statistics, their lost-time injury rates (per 200,000 man hours) were significantly lower than those of the rest of the industry (Figure 2) (5.4 to 7.2 vs. 10.2 to 11.0). These lower accident rates translate into substantial cost savings, as well as improved productivity. Related studies[2] of safety performance support these findings, showing that mines with lower injury rates tended to have higher productivity, better labor-management relations, clearly enforced safety policies, and more worker participation in job management. An evaluation of incentive programs as used in mining[3] shows that they are generally ineffective, but the study identifies probable means of correcting these problems.

Safety improves in high-productivity mines, but dust and noise also increase with higher productivity; as an example, on longwalls, the average shift production has risen from about 850 tons in 1978 to 1,968 tons in early 1987--an increase of 132 percent. We anticipate that output per face will increase by another 28 percent by 1995. This means that by 1995 dust will also increase by 28 percent. Because the average dust level of longwall mining sections is already near the 2.0 mg/m^3 standard, future increases in coal output may be constrained by a lack of dust control technology, with a loss in potential revenues of $584 million. Even today, many operators make unidirectional cuts to keep dust levels down, so production already suffers from dust constraints.

On continuous miner sections, which account for two-thirds of underground coal production, the average dust level is about 1.5 mg, suggesting that a moderate production gain would not create substantial compliance problems; however, this overlooks the

reduced standards problem due to quartz. About 40 percent of the respirable dust samples analyzed by MSHA contain more than 5 percent quartz.

Already, 32 percent of all U.S. coal mines, employing 67,500 workers in surface and underground occupations, have reduced standards averaging about 1 mg/m^3. To cut dust levels in half is not easy and MSHA has indicated that a significant number of these mines cannot comply with these more stringent standards. Citations for reduced standard violations are among the most frequent imposed by MSHA and reduced dust standards will continue to cause economic loss for the industry and its workers.

Thus the future needs are clear: Technological innovation and revolutionary changes in labor/management relations are required to ensure a safer, more viable industry that is competitive in the world market. Because this meeting is predominantly coal-oriented, I have used coal statistics to make my point, but these observations are proportionally applicable to metal and nonmetal mines.

Cost Implications: The Bureau has developed an Accident Cost Indicator Model (ACIM) that calculates the estimated cost of mining accidents based on MSHA accident data, regional medical costs, wage scales, injury severity, and price of coal, which are combined to obtain a picture of the cost of the mining accidents to the industry, the public sector, and the miner's family. The model shows that lost-time accidents typically cost $7,000 to $13,000 and fatalities cost from $800,000 to $1,200,000. When tested against a sample of 486 mining accidents in 1981, the model computed conservative estimates of the actual costs, on average 11.5 percent lower than the actual costs. This error in estimation is acceptable for an estimation model where many factors are still unknown. The model is accurate enough to be very useful for both research and policy decision making.

The ACIM has been used extensively for addressing health and safety research questions as well as for determining where costly hazards exist. For instance, analysis shows that ACIM total costs for all fatal and lost-time underground coal mining accidents came to over $100 million in 1987; over $20 million (20 percent) of the total cost accident was due to groundfall fatalities (Figure 3). This analysis reinforces the opinion that groundfalls tend to result in fatalities more often than other types of accidents, and account for a major portion of the accident costs to miners, the industry, and society.

The ACIM is an invaluable research and policy tool when used in conjunction with other safety and productivity databases. Its accuracy has been shown to be very acceptable for a statistical estimation procedure, and its use is much less expensive than the collection of data on the actual costs of every mining accident. It provides a method for placing more emphasis on types of accidents where the outcomes tend to be more severe (e.g., groundfalls, etc.), so that a balanced research program can be maintained.

INTERNATIONAL COMPETITIVENESS

In 1987, the United States was the world's second largest coal exporter, next to Australia. We exported 79.6 million tons of coal, or approximately 21 percent of the coal traded in world markets. In addition to Australia, the U.S. coal exports competed with major suppliers from seven other countries, including South Africa, Poland, the USSR, and Canada. Until 1984, however, the United States was the largest coal exporter. Our coal exports were over 100 million tons as recently as 1982. Since then new sources of low-cost coal, primarily from Columbia and China, have

displaced U.S. coal exports to Europe and Asia, respectively.

As a result, the future of U.S. coal exports is not promising at the present time. Although the total world coal trade is expected to expand from the 1986 level of roughly 370 million tons to about 500 million tons by the year 2000, U.S. coal exports are not expected to exceed 91 million tons.[4]

Assuming a constant demand for energy, increased sales of United States coal can be achieved in two primary ways: 1) as a substitute for another fuel (i.e., interfuel competition), and 2) via increased coal exports. In a study by the Energy Information Agency for the Bureau of Mines, EIA concluded that, given certain assumptions, U.S. exports would increase substantially if our mining costs were lowered by at least $8 per ton in the year 2000. The study suggests that as U.S. mining costs are reduced, total U.S. exports will expand only slightly until the costs are $8 per ton below the base case levels. At that cost level, U.S. coal exports will surge by 53 million tons (46 percent) above the base case level of 114 million tons to 167 million tons, and U.S. steam coal will displace significant quantities of South African coal in Europe. U.S. exports will continue to expand to about 250 million tons in the final $20 per ton cost-reduction case covered in the study. At this level U.S. coal will be cost-competitive with South African and Australian supplies in both the European and Asian markets. China, Venezuela, and Columbia are the lowest-cost supplies and will maintain their markets (per the study), limiting further expansion by the United States.

While a $20 per ton reduction is conceptually realizable, an $8 per ton reduction is realistic and the results of implementing it can be quite significant.

As we have seen, poor safety has adverse cost, social and humanitarian implications. Further, some dramatic improvements in the export position of coal could be realized based on a rather modest reduction in the cost per ton. However, coal is coming under increasing pressure in terms of acid rain. It is not a question of whether there will be acid rain legislation, but of what the impact of legislation on the coal industry will be. I am convinced that clean coal technology will be a technical success, but at an economic price. Hence, as we look at the domestic energy market, we must recognize that the cost of energy from coal will undoubtedly increase, unless other changes are made to compensate for the cost of additional coal cleaning and/or smoke stack cleaning.

The challenge is clear: we have a mutual need and desire to improve health and safety, and we must lower the cost of producing coal if this industry is to remain competitive in the domestic market, and in order to regain the competitive edge once held by the U.S. coal industry in the international market.

I believe that these challenges can be met through the utilization of new technology and the more effective use of the invaluable human resources (both management and workers) that make this industry as great as it is today.

Mines have become safer and more productive over the years; and let me use the following to reinforce that point:

- During 1973-1985, coal production increased by 48 percent and fatalities decreased by 48 percent. In 1973, there was a death for every 4.5 million tons mined, and in 1985 there was a death for every 13 million tons mined--an improvement of nearly 190 percent.

- Roof falls claimed 181 lives during 1980-84. Some 5,300 people suffered non-fatal injuries due to this cause. In

1987, roof and rib falls in underground coal mines were responsible for 30 percent of all (64) fatalities.

There is, however, a lot more that needs to be done:

- Thirty percent of all miners suffer a major hearing loss.
- Back injuries represent the single largest category of lost-time accidents in underground mines.
- Cable handling, the second most hazardous activity (after material handling) is responsible for 16 percent of the injuries.
- In fiscal year 1988, the number of new black lung claims filed was 6,981. As of September 30, 1988, people receiving black lung benefits number some 157,000.
- Manual gas tests are made every 20 minutes while mining, resulting in increased hazard exposure and reduced production.
- During 1983-87 reported fatalities at the face were 32 percent of all fatal accidents in underground coal mines. Additionally, some 27 percent of all lost-time accidents occurred at the face.

Recognizing these problems, the Bureau is pursuing new and innovative solutions to ensure a viable, and safe, coal mining industry. Let me share with you some of these developments:

IMPROVED SENSING

Numerous innovations are about to emerge related to sensing, but I will list several here in order to make my point:

Bureau research in remote sensing has demonstrated that linear features of the Earth's surface mapped from Landsat satellite images can be useful in determining potentially unstable roof rock zones in underground coal mines. The geologic lineaments are often caused by subsurface fracture systems that can extend through to the mine level. Such fracturing can cause ground instability and lead to safety hazards and disruption of the mining process. Identification of these surface features prior to mining can aid in mine planning.

Other Bureau research programs are investigating the application of microseismic data collection for monitoring the stability and behavior of the rock strata surrounding underground mining operations. As underground excavation occurs, the various rock formations are subjected to changing conditions of load and stress. The rocks oftentimes respond to these changes by emitting audible energy called rock noise. There have been a number of studies which identified a strong correlation between the magnitude and rate of these noise emissions and the failure of the rock mass. Further developments in this field will prove beneficial to hazard identification for underground mines and will advance our understanding in the field of rock mechanics.

We expect little change in the number of mine workers in the near future. However, skills required will change to some extent. Any (minimal) displacement of workers will in the long run be outweighed by the need in service and related work areas. Education, training, and cross-training will be required in order to achieve the maximum benefits of the research. Greater production capacity will increase the need for additional mine workers in the long run. Success of this program depends on active participation and cooperation of all concerned--mine management, mine workers, and regulatory agencies, among others. Input is needed in the areas of improved safety and required changes in regulations. Equipment manufacturers will participate in the necessary equipment design changes at

a much later date. It is again to be emphasized that these changes will come about very gradually.

HUMAN RESOURCES

Previous Bureau work focusing on integration of technology and human factors has met with some success but much research remains to be completed. The full potential of an integrated approach using both technology and human factors has not as yet been achieved. The potential competitive benefits of a better fit between technology and human resources is, however, very clear. The Bureau of Mines study[2], previously referenced, that evaluated some of this country's highest-producing continuous mining sections bears directly on this issue. This study found that technological factors such as extended lifts, supersections, and diesels could improve productivity by up to 30 percent; however, technical factors could not explain how these mines were able to produce tonnages 400 percent greater than the continuous miner national average of 368 raw tons per unit shift. The 25 high-producing mines were using the same technologies available to less productive mines. Results of the study showed in no uncertain terms that tremendous productivity gains were attainable only through concentration on the human element. Another interesting finding was that half of the 25 high-producing mines were formerly average producers that had turned themselves around by improving the fit between technology and human capabilities. Also, the high-producing mines did not compromise health and safety in order to achieve high tonnage output. In fact, the high-producing mines experienced only one third of the accidents experienced by average-producing mines. The main characteristic that distinguished these high producers from the rest of the industry was a prevailing climate of labor-management cooperation and trust.

Human factors research also focuses on the performance and psychology of the individual worker. Studies in various industries have determined that between 50 and 80 percent of all accidents and injuries are related to inadequate human performance. The Kentucky Department of Mines and Minerals estimates that 88 percent of all mining accidents in that state are attributable to incorrect performance. Using these estimates, it is projected that over the next 20-year period, the mining industry will have a minimum of 1,830 fatalities and 219,575 lost-time injuries related in one way or another to human performance errors. While evidence indicates that human error is often a consequence of poorly designed equipment and mining systems, the fact remains that many accidents occur because poor decisions were made by the person or persons involved. As mining systems become more complex with the introduction of new technologies, the need to make appropriate decisions in the face of non-routine occurrences will undoubtedly become greater. Research indicates that few people, even those in critical positions in mining, are adequately trained in the essential skills of decision-making. A growing body of research indicates that judgment and decision-making are, however, teachable skills. Improved, more effective training methods can be developed based on an understanding of the psychological processes that precipitate unsafe performance.

At least two significant conclusions can be drawn from the work just discussed. The first is that it is possible to achieve higher productivity and a safer work environment by utilizing current technology and placing major emphasis on the human element in the work process. Second, it is clear that much more needs to be known concerning how to effectively utilize human resources, and control human performance in mining work places.

The Bureau is in the process of developing the necessary technology

for creating computer-assisted mining machines that will be capable of automatically tracking a coal seam and extracting only the desired material (e.g., coal only, leave some top and/or bottom coal, or extract some roof and/or floor and coal). If successful, this research should yield significant increases in worker safety, mining productivity, and quality of coal extracted.

The most critical element associated with providing an automatic horizon control for cutting module of a computer-assisted mining machine is an "intelligent" coal interface detection (CID) system. This CID system must be capable of measuring one or more distinguishing geophysical properties of coal and the adjacent formation and then making intelligent decisions such as identifying what type of geologic material is being cut, locating the coal-rock interface, and determining the thickness of the coal remaining above the excavated roof or below the excavated floor.

In 1987, the Bureau began the task of reexamining the CID problem as both sensor and computer technologies had advanced significantly during the preceding 30 years. In addition to the natural gamma radiation concept, several other promising CID techniques are currently being investigated by the Bureau. These include adaptive signal discrimination of machine vibration, infrared thermography, x-ray fluorescence, and synthetic doppler radar. Field tests of these techniques are currently underway.

CONCLUSIONS

Some of you may feel that the picture for the future is not clear, but I suggest that this is not the case. The industry faces many new challenges, but the means to address them is clear and unfolding before us. The emerging technology and the understanding of the means by which we can ensure the safe and full participation of the industry's workforce, both management and labor, provides all of us with opportunities for a bright and challenging future. For us to achieve these common objectives we must continue to work together; this conference, as it has in the past, provides one of the important forums in which to formulate a basis for the continued cooperation to ensure that coall will continue to be a more safe, dominant and viable energy source, both domestically and abroad.

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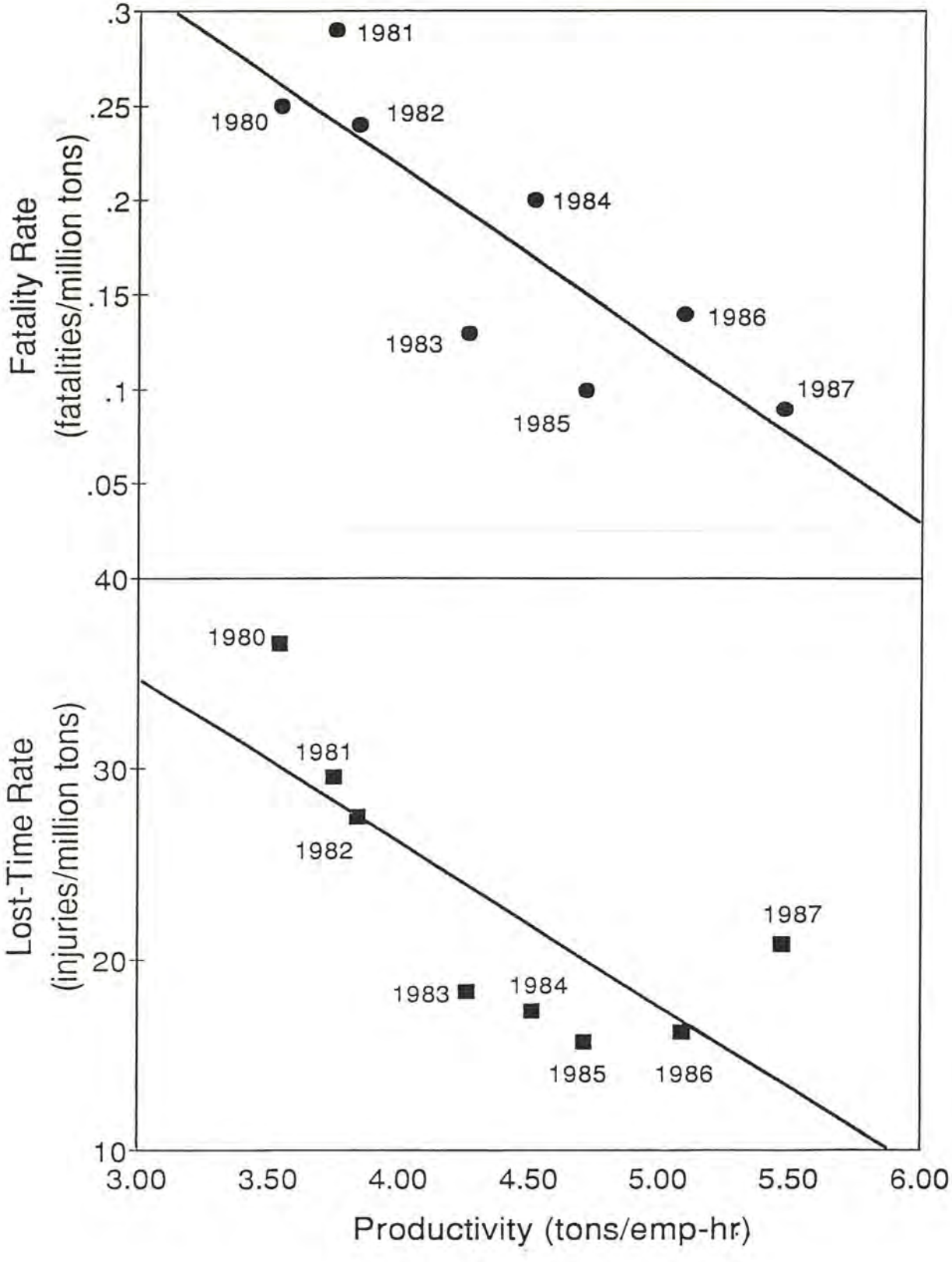
3 Goodman, P., "Determining the Effect of Incentive Programs on the Occurrence Accidents, Injuries, and Productivity (contract J0145012, Carnegie-Mellon Univ.)," BuMines OFR 47-88, 1988, 143 pp.; NTIS PB 88-234257.

4 "Annual Prospects for World Coal Trade 1988," DOE/EIA - 0363 (88) (May 1988).

Figure 1.- Relationship of fatality and lost-time injury rates to productivity for the bituminous coal mining industry, 1980-87



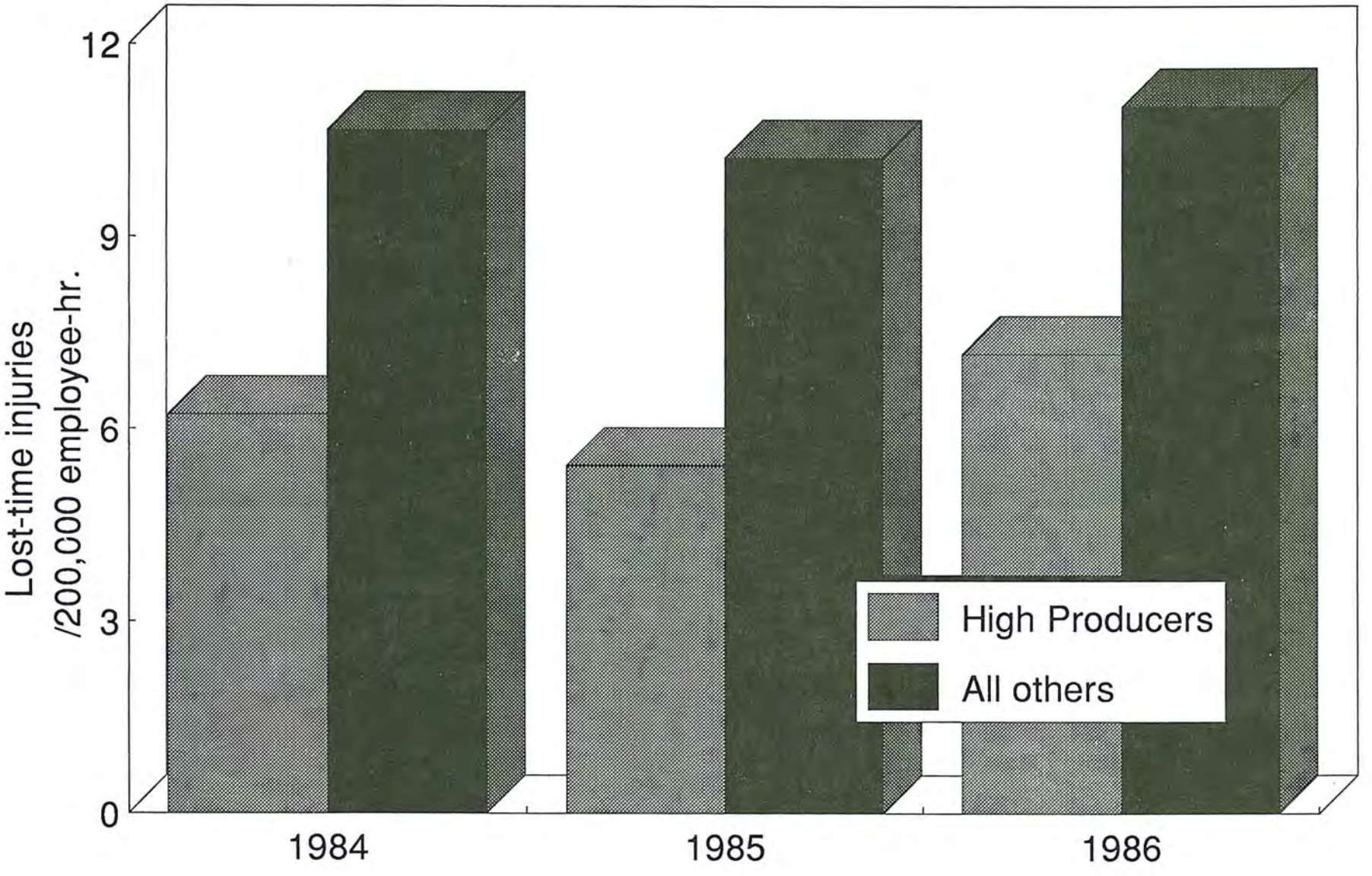
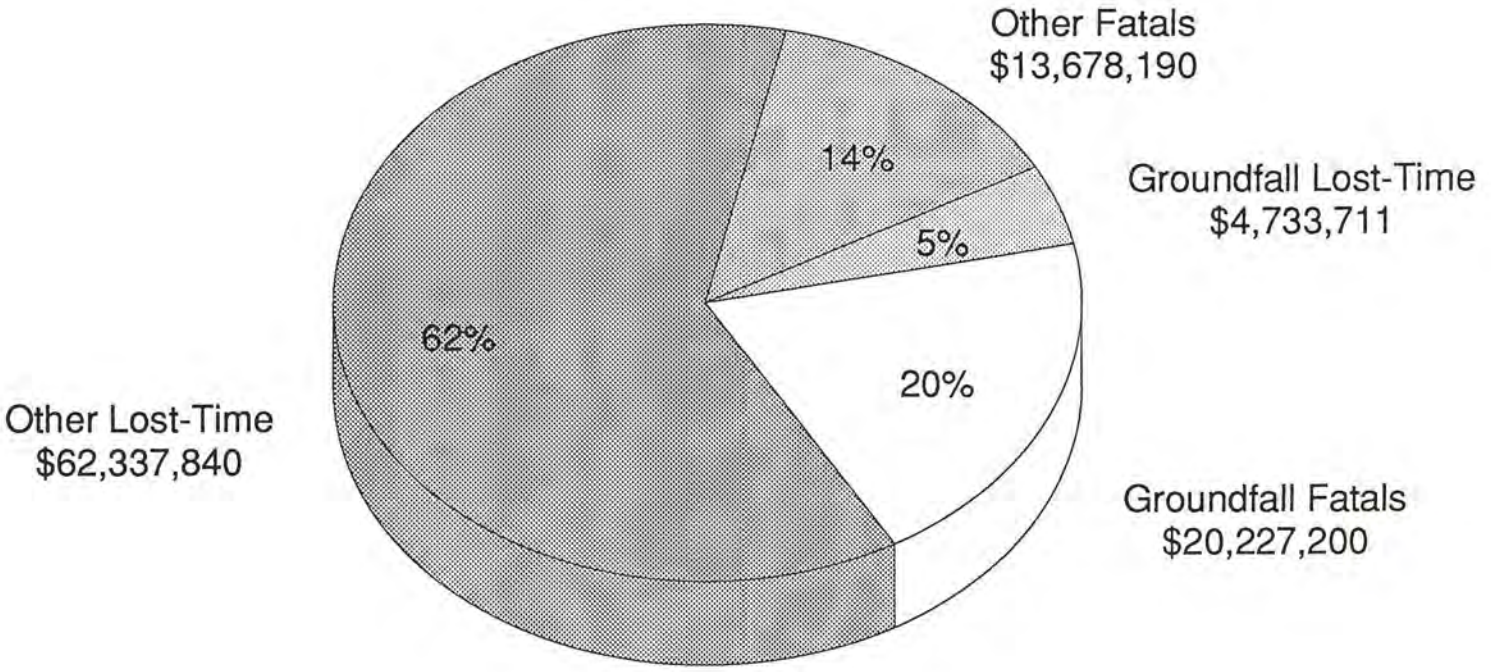


FIGURE 2. - COMPARISON OF ACCIDENT RATES FOR HIGH-PRODUCTIVITY MINES AND THE REST OF THE COAL MINING INDUSTRY, 1984-86

FIGURE 3

Costs of Fatal and Lost-Time Underground Coal Mining Accidents, 1987



Total Cost = $100,976,940

ADDRESS

Roy L. Bernard

Deputy Assistant Secretary of Labor for Mine Safety and Health
August 29, 1989

It's a pleasure to be a part of this event. For 20 years, this Annual Institute on Coal Mining Health, Safety and Research has been the single most important conference focusing on safety and health in the coal mines.

We in the Mine Safety and Health Administration are proud to be co-sponsoring this conference. And we are glad to see how many people have been able to attend.

This year's Institute is especially significant because it also marks the 20th anniversary of an important mine safety law. It was twenty years ago that Congress passed the Federal Coal Mine Health and Safety Act of 1969. The 1969 Coal Act was probably the strongest job-safety law that had ever been passed in the United States. Then in 1977, Congress amended the 1969 act and expanded it to cover all mines, including metal, nonmetal, stone, sand and gravel as well as coal. Today, the Federal Coal Mine Health and Safety Act of 1969 still forms the basic foundation for our activities in the Mine Safety and Health Administration.

Safety and health conditions in the coal mines have come a long way in the 20 years since Congress enacted the 1969 law. Fatal accidents are at the lowest levels in history. This morning, I want to review the 20 years of safety progress that brought us to this point, and I also want to talk about a few safety and health problems that we are especially concerned about in the Mine Safety and Health Administration.

From our viewpoint, there are still too many accidents and potential health problems in some mines. Specifically, these concerns are:

-- Illegal mining;
-- Accidents that involve independent contractors;
-- The use of diesels underground;
-- Safe methods of ventilation for underground conveyor belt areas;
-- and, finally, enforcement actions at mines with a pattern of violations.

Let's think back for a moment to the year 1969. Do you remember where you were, what you were doing?

Everybody remembers 1969 as the year that the United States first put a man on the moon. Richard Nixon was President, and the single most controversial public issue was the war in Vietnam.

You may remember that in 1969, Broadway Joe Namath was at the height of his glory as the New York Jets surprised just about everybody by taking the Superbowl. In the grocery store, you could get U.S.D.A. choice sirloin steak for $1.09 per pound. A loaf of broad cost 20 cents. Gas would run you less than 35 cents a gallon--and they would pump it for you at that price!

I was a young mining engineer in 1969, working in the Bureau of Mines in Duluth, Minnesota. I remember that mine health and safety were very much in the news that year. The Farmington mine disaster had claimed 78 lives only the previous November.

Witnesses in Congressional hearings displayed x-rays of coal miners' lungs, and West Virginia miners walked off the job to dramatize their demand for black lung benefits.

During that year, 1969, the coal industry employed about 133,000 miners--which is several thousand fewer miners than today. As of last year, there were about 156,000 coal miners, compared with 133,000 miners 20 years ago. (Those figures do not include people working in the office).

Yet in spite of the lower employment level, the year 1969 also saw 203 coal mining fatalities. In comparison with today, that was poor safety record. But at the time, it was a historic low in fatal accidents.

Both health and safety concerns contributed to passage of the 1969 law. That law brought the industry more frequent inspections, penalties for all violations, new safety and health standards, and compensation for miners who had contracted black lung. For the Bureau of Mines, the law brought a sudden expansion in safety and health programs. When the law was passed, the Bureau had 200 coal mine safety inspectors. The law called for the Bureau to inspect every underground mine in the country four times a year, and every surface mine twice a year. More inspectors had to be found.

Bureau employees hit the circuit, traveling around mining areas, talking to miners about inspector jobs, handing out job applications, holding job interviews on the spot. In a storefront facility in Beckley, West Virginia, the National Mine Health and Safety Academy got its start as mine safety instructors began training the new inspectors. Experienced inspectors took on supervisory and management roles.

At the same time, the Bureau was required to revamp and reissue all existing safety standards for coal mines, while adding new standards in both safety and health. Technical personnel made extensive surveys in order to build up a more complete picture of dust conditions in the mines. Administrative systems were set up to handle citations and penalties.

The industry also had to make adjustments. These adjustments came easier for some than for others. As one Bureau of Mines official used to say, "the bravest man I ever knew was the first inspector to issue a citation in eastern Kentucky." Twenty years ago we also saw the start of many cooperative programs that continue today, including:

-- Federal grants to state mine safety and health programs;
-- Winter alert; and
-- Regular technical conferences on mine safety and health...like this one, which is marking its 20th anniversary today.

A lot has changed since 1969. I mentioned that coal mine employment is higher today than it was 20 years ago. Productivity also has

increased, in both underground and surface mining. Last year the industry set a historic record in coal production.

Last year, too, fatal injuries in the coal industry numbered 53. That is 53 too many. At the same time, it is real progress compared with 1969, when there were two hundred and three fatal injuries.

Today the coal mine inspection workforce numbers more than 800. At the National Mine Health and Safety Academy's modern campus in Beckley, some 18,000 people per year participate in educational programs. Among them are promising young inspectors and specialists who have been selected for special preparation in advance of possible promotions--a supervisory training program that was singled out recently for praise by the Federal Merit Systems Protection Board. The academy even entered the space age last year when it began to broadcast mine safety and health training sessions by satellite.

Contributing to safety in the last 20 years have been many new items of safety technology--panic bars, cabs and canopies on mobile equipment, automatic brakes, and better mine lighting systems to name just a few. In the last few years, automated temporary roof supports have helped to reduce accidents involving falling roof rock.

Dust control isn't perfect yet, but most mines are consistently meeting a standard of 2 milligrams of respirable dust per cubic meter of air. That is much better than 20 years ago, when we measured some areas of some mines at 30, 40 or even 50 milligrams of dust per cubic meter.

Once again, we are updating regulations--this time, in light of greater experience and advancing technology. With the amendments in 1977, mine safety enforcement moved to the Department of Labor, and this agency received its present identity. Those amendments also strengthened the role of miners in safety and health--notably, through provisions for miner training. Today, communication on safety and health is stronger than ever. Coal mine managers can be heard talking about safety and health management as integral to running an efficient and profitable mine. Thousands of miners receive training annually through an expanded state grant program that now includes 45 states. There are dozens of mine safety and health meetings each year, large and small, around the country.

At the same time, there is more that needs to be done. I want now to discuss just a few selected areas where we in the Mine Safety and Health Administration have some current concerns. I'll describe some things that we are doing about those concerns, and I also want to ask for your help.

This isn't intended as a complete catalogue of everything that we are doing in the Mine Safety and Health Administration. What I want to do is touch on what I believe are <u>the</u> most critical areas at this point in history.

As I mentioned earlier, those concerns are:

-- Illegal mining;
-- Accidents involving independent contractors;
-- Use of diesel equipment underground;
-- Ventilation in underground coal mines, especially conveyor belt areas; and, finally,
-- Enforcement measures for mines with a pattern of violations.

<u>First, illegal mining.</u> I'm talking here about wildcat mines that are not registered with our agency or with other authorities. It was at a surface wildcat operation in Kentucky that the

operator of a road grader was killed just last month when his machine plunged off a bridge in the early evening. Miners at an unregistered mine such as this one lack the most basic protection that comes from federal inspections and proper training.

In case after case of tragedies at wildcat mines over the years, investigations have found that lack of safety training, inexperience, and sloppy work practices and housekeeping often played a part in such accidents. Last year, we were concerned to hear from some of our inspection people that they had been encountering a number of wildcat operations. Based on their reports, we felt that wildcat mine activity might be increasing--although we cannot say by how much, because if we were in a position to count illegal mines, they wouldn't remain in business as illegal mines for long. We decided, however, that it was time to make a concerted effort to stamp out illegal mining.

To put a stop to wildcat mining and the dangers it brings, we started a new program with a national coordinator at headquarters, regional coordinators in our districts, and a special investigation task force to assist their efforts. The federal office of surface mining and the state of Kentucky also joined with us in order to share information. To date, there have been 36 cases of possible illegal mining investigated under this program. Our aim is, ideally, to get all illegal operations properly registered and inspected. Otherwise, an operation may be closed. If these efforts fail, legal action--including criminal prosecution--may result.

As of last month, four individuals had entered guilty pleas to criminal violations of federal mine safety law for operating two wildcat mines in Knox County, Kentucky. Not only were those mines illegal, unregistered operations: they were unsafe--with inadequate ventilation, inadequate roof support, and no proper pre-shift examinations.

MSHA's position is that wildcat mines hurt everyone in a community. In addition to endangering their employees, these operations also evade taxes and often destroy the community environment with no thought of repairing the damage they leave behind. In the near future, we expect to broadcast public service announcements about the illegal mine program. We will ask people to help us by coming forward with any information that can in order to help stamp out illegal operations and protect miners.

That is one high-profile concern at our agency today. Another is <u>accidents involving independent contractors</u>.

As I mentioned earlier, coal mine fatalities have been reduced to the lowest levels in history. Yet there is a group of employees that has a higher-than-average rate of fatal accidents: employees working for independent contractors at mines.

Last year, there were 53 fatal accidents in the mining industry. Of those, <u>nine</u> of the victims were not directly employed by the mine operator, but were employees of independent contractors.

The <u>rate</u> of fatal accidents for workers employed directly by coal mine operators was just .03 fatalities per 100 workers. But the rate for contractor employees at coal mines was .11. A rate of .11 compared with .03 for regular miners is a big difference and is a cause for concern about contractor employees.

In addition, all of the contractor fatalities last year were on the surface--which normally

should be a fairly low-hazard area.

We in the Mine Safety and Health Administration are not certain of the reason for the trend in fatal accidents among contract workers, but it has been there for several years. We are looking into the reason for this problem and for possible solutions. New regulations are not necessarily the answer, but some extra training may be in order.

We have sent out a memorandum to the industry in an effort to alert mining people to the problem of fatal accidents involving contractors. There was also a form that could be used to order training materials on this subject from the National Mine Health and Safety Academy. Let me urge everyone who works with contractors to order these, if you have not done so. Also, if you employ independent contractors at your operation, let me urge you to take an extra hard look at the safety of these people. These employees should not be an exception to the good safety trends among coal miners in general.

A third major safety and health issue today is use of diesel equipment underground.

The last decade has seen a trend toward greater use of diesel equipment in underground coal mines. As of last year, there were some 1,300 units of diesel-powered equipment used underground in the coal industry. Diesels may have both health and safety implications in coal mining. Fire and respiratory hazards have been among the most prominent concerns over diesels.

Last year, an advisory committee appointed by the Secretary of Labor gave us its report containing recommendations on new regulations to protect coal miners where diesels are used underground. The committee included representatives of industry and labor, along with a majority of other members who were neutral experts. They reached a consensus that included a variety of recommendations on diesel equipment approval, use, health protection and further research.

Today, we are publishing a proposed new rule on air quality that covers coal, metal and nonmetal mines. (Note: publication date is August 29, 1989). Among other features, our air quality proposal includes health provisions that derive from the diesel committee's recommendations. Before the end of the year, we expect to publish another proposal concerning safety and health standards for diesel equipment use. With diesel use becoming a strong trend, underground coal miners who work around this type of equipment deserve the most effective health and safety standards we can devise. I hope that you will assist us in that effort.

Fourth among the leading health and safety concerns is ventilation in underground coal mines, specifically ventilation of belt conveyor entries.

The ventilation of belt entries has long been a topic of controversy. In the Federal Coal Mine Health and Safety Act of 1969, Congress specified that air velocity in belt entries should be kept as low as possible. They had three aims in mind: to avoid fanning any fire that might break out along the belt, to slow the movement of fire gases in the same situation, and--in general--to reduce suspended coal dust in the air. In addition, Congress specified that air from the belt entry should not be used to ventilate the working face.

However, at the same time Congress recognized that mines differ in important ways. In certain situations, equal safety can be achieved by alternate methods, or methods other than following the

required safety standards. Sometimes, too, following the regular standards might actually reduce safety. Congress therefore provided for exceptions, through petitions for modification.

Based on an investigation by the Mine Safety and Health Administration, which showed that it would be as safe or safer than following the regular standard, a number of underground coal mines currently use belt air at the face. There are some people, however, who have opposed allowing belt air at the face. Recognizing their concerns, MSHA Assistant Secretary Dave O'Neal earlier this year assigned a special panel of specialists from our agency to look into a broad range of questions surrounding the issue of how conveyor belt entries should be ventilated. The review panel compiled a great deal of information, and they made actual mine measurements. The report was released last week. This is not the place to go into all the details, but I hope that all of you who are concerned with coal mine ventilation will read this report on an important topic.

For instance, the panel found that safe escape from inby a belt entry fire can best be assured by protecting the intake escapeway from fire contaminants, by providing early warning of the fire, and by training miners in proper emergency escape procedures. The physical separation of the belt entry from the intake escapeway is essential so that miners will have an escapeway to the surface in case of fire in the belt entry. This physical separation is required by present MSHA standards. Nevertheless, some air leakage through stoppings is inevitable--even through the best-built and maintained stoppings. Stoppings "breathe." Air moves through a stopping whenever there is a difference in air pressure on the two sides. In a fire, this can mean smoke leakage into areas that you might have expected to remain smoke-free. Ventilation plans and emergency escape plans therefore need to consider the relative air pressures in adjacent entries.

I won't go into more detail here, but let me emphasize that the report on belt ventilation is worth studying. Among other things, the investigators concluded that using belt air at the face, and with proper precautions, can be as safe as any other method of ventilating the belt entry. Equally important, the panel that made the study suggested a number of improvements to enhance miners' safety. We plan to take action in such areas. Additional safety improvements may be addressed through regulatory action.

We would like to have your comments on those issues in the report that are relevant to MSHA's revision of our underground coal mine ventilation rule. These can be sent to our standards office at MSHA headquarters. We are especially interested in receiving comments on certain findings and conclusions in the report which we will consider in drafting the final ventilation rule. These are: protection of the intake escapeway from leakage from adjacent air courses; the use of belt air to ventilate working places; protection of the intake escapeway from fire sources; the use of smoke sensors; and air velocities in belt entries.

One last area of concern I would like to mention, and I'll be brief: Mines with a so-called "pattern of violations."

Special enforcement sanctions when mines have a pattern of significant and substantial violations were included by Congress when the mine safety law was last amended. This spring, we issued a proposed regulation spelling out how we intend to carry out this provision of the law. The proposal

specifies criteria we would use to identify mines as having a pattern of violations. There are procedures for notifying the mine operator of the pattern of violations, and providing for all affected parties to respond.

Once a mine is officially in a "pattern" status, every significant and substantial violation found at that mine would result in an order of withdrawal. This would continue until the mine has a so-called "clean" inspection, with no serious violations.

The regulation on patterns of violations will give our agency another enforcement tool in certain cases where mines have persistent safety problems. We are holding the comment period for this proposed regulation open until the end of this month. Again, I hope that you will supply us with any comments, suggestions, and insights you may have.

Those have been a handful of the most notable areas where we in the Mine Safety and Health Administration believes significant safety and health progress is possible--and soon. There are many others.

Looking back to 1969, this industry has come a long way in terms of safety and health. Fatal accidents have been cut to one-quarter of what they were. Coal mine dust has been reduced, in most cases, to safe levels. We are seeing better training, better safety and health technology. Twenty years from now, it will be the year 2009. By then, it present trends continue, a coal mining fatality will be a rare event.

By then, many of us will be retired, and a new generation will be mining, a new generation will be looking after health and safety in the mines.

In their eyes, you and I, all of us--working together to improve safety and health--may go down in history as the generation that brought mine safety into the 21st century.

Let's work together and see how much more we can do.

MILESTONES OF THE TWENTY YEARS OF THE COAL MINE HEALTH AND SAFETY ACT

Joseph Main
Administrator, Occupational Health and Safety Department
United Mine Workers of America
August 29, 1989

Twenty years ago the United States Congress responded to outcries from coal miners across the country. Coal miners were demanding an end to the human suffering, the injuries, the deaths and the dreaded disease known as black lung that were being heaped upon them in the nation's coal mines. They were demanding that Congress take action to require coal mine operators to run their mines safely. They were demanding that a government agency be created that would police the mines to make sure they were safe. Coal miners were tired of working for mine operators who ran coal mines like death traps. They were tired of having a government agency that, from their viewpoint, cooperated with these mine operators at the expense of their very lives.

In 1969 coal miners across the country were revolting against the system, a system which protected the coal operator who refused to spend the money necessary to maintain safe coal mines. Coal mine operators' refusal to employ necessary protections for miners was the standard of that day because government health and safety requirements were sub-standard and, further, because the government agencies did not effectively police the mines to make them safe.

In 1969 Congress acted to stop the tragedies in the nation's coal mines, in response to these miners' outcries, by passing the Landmark Coal Mine Health and Safety Act of 1969. But why did it take so long and why did so many have to suffer and die before that happened?

The lessons coal miners have learned over the years is that they cannot trust coal mine operators to protect them from the harsh elements of mining coal that threaten their lives, their health and their bodies, and they cannot trust the government agencies charged with policing the mines, who far too often become sympathetic to operator production wants at the expense of miners' health and safety. History has taught them that.

Congress, in the passage of the Landmark 1969 Coal Mine Health and Safety Act, changed much of that when they set specific health and safety rules to be followed and when they created a government policing agency with the power and tools to see that those rules were complied with. But it did not eliminate mine operators' inherent resistance toward compliance or the federal agencies biases toward mine operator production--those are still clear and present threats to miners across the nation.

It is important to remember why the Federal Coal Mine Health and Safety Act of 1969 and the amended act which is the Federal Mine Safety and Health Act of 1977 were passed

and to recount accomplishments.

It is a common but overly simple formula to state that the 1969 Act was passed as a response to the Farmington, West Virginia disaster. We know the story: 78 miners died in a massive explosion at Consolidation Coal Company's No. 9 mine. That mine remains sealed to this day, with 19 bodies entombed.

This was the first time that television brought live coverage of a mine disaster into the nation's living rooms. The outcries of the miners reached the conscience of the nation. They were shaken and Congress responded by passing the Coal Mine Health and Safety Act of 1969. This is clearly part of the background for passage of the Act, but only part. Other factors stand out. Miners were protesting the unhealthy conditions in the mines which were robbing them of their health. Miners were protesting over the safety conditions in the coal mines, with deaths in the hundreds each year and miners being disabled by the thousands. Miners in the state of West Virginia had been agitating for many months for passage of a bill to provide compensation for black lung. Progress was painfully slow. Eventually, they resorted to a strike that spread fast, much faster than many anticipated. The desire for just compensation for their dreaded disease and for cleaning up of conditions was deep. That desire remains. Mines were shut down in three states. The result of this activity was a compensation plan for West Virginia miners. This plan provided the stimulus for the federal black lung program that was incorporated in the 1969 Act.

Another factor in the passage of the 1969 Act was that virtually all other government efforts to control risk of fatal injuries in coal mines --such as state mining departments and federal acts in the 50's and 60's--were ineffective at controlling even the best-understood hazards. The rate of fatal injuries remained unacceptably high during the decades of the 50's and 60's. Government policy that relied on the good will of the mine operators, that depended on them to voluntarily comply with existing safety codes, was a failure--a total failure. Government agencies also let health and safety take a back seat to operator production wishes. Something new was needed. The 1969 Act was proposed to remedy this situation.

This act was remarkable in its day and remains so. It marked a shift from an era of a nearly unregulated mining industry to one in which inspections were mandatory and frequent, in which specific health and safety standards were mandatory, in which penalties were mandatory, in which inspectors could shut down all or parts of mines and in which miners had significant rights to participate in the setting and enforcement of standards and were promised protection from discrimination. The Act created a stringent standard for exposure to respirable coal mine dust, phased over three years. There were many with serious doubts that the respirable dust standard could be met. Not all of the promises embodied in this act were kept, but many were.

Support was not unanimous. A spokesman for a coal operators' association (George Judy) said, "I don't think you can legislate safety. I don't know as I like <u>any</u> of it [the 1969 Act]." Mine operators challenged the constitutionality of the Act but this effort failed. Coal mine operators tried other efforts to block passage of the Mine Act. They faced a serious problem, however. The industry had a record of death, disablement, disease and disaster after disaster. In the five years just prior to 1969, well over 1,200 miners had been killed on the job. The

operators' efforts to squash that legislation failed and the landmark law passed. Despite claims to the contrary, that act was enormously successful. Coal mine fatalities came down. The average number of deaths in the 1960's was 266. The average number of deaths in the 1970's was lowered to 155. Dust levels came down significantly also, defying the nay-sayers. If one were looking for measures of efficiency, they were not hard to find.

Some claim the cost was too great. There were initial monetary and production costs associated with compliance with the Mine Act. Those costs were, however, the direct result of an industry's neglect over the years on a national scale, which had to be rectified. Let me merely point out that productivity in our mines is the highest ever. We are now producing more coal than at any other time in our nation's history, and with one of the smallest labor forces.

In the mid-1970's the health and safety improvements brought about by the Mine Act were noted, as were the shortcomings, and Congress began to focus on those. Following the double explosion at the Scotia Mine in 1976, which claimed 26 miners' lives, public attention was again focused on the conditions coal miners had to endure. Congress acted again and in 1977 amended the 1969 Act.

In the passage of the 1977 Act Congress moved enforcement authority from the Interior Department to the Labor Department, metal and non-metal mines were placed under the Mine Act, specific training requirements for miners were added, the federal agencies' enforcement powers were strengthened, and miners rights to participate in enforcement activity were strengthened, as were their protections. The 1969 Act was successful, but Congress saw that more needed to be done. Congress found that the kind of thinking embodied in the 1969 Act worked and should be broadened in order to extend benefits to other miners. Miners outside of the coal industry were not receiving equal protection under the law. Enforcement, the critical element in the 1969 Act, was to be strengthened by moving responsibilities out of the Department of the Interior, which had the conflicting responsibility of promoting and supporting the mineral industries. Enforcement was to be strengthened, stimulated in part by the Scotia Disaster in 1976. Civil penalties were to be increased. Miners' representatives were to be given the right to travel with federal inspectors in order to improve mine-site inspections. There were other improvements. The 1977 Act was a clear vote of confidence in the basic approach created with the 1969 Act.

What has happened since then? For one thing, many of the lessons of the 1969 and 1977 Acts have been ignored. Let me illustrate my concerns by describing government response to several other milestones, which shows things were somewhat different in the 1980's. First, I will address mine disasters and accidents. In the 1960's and the 1970's mine disasters were examined with the forethought of forcing changes in order to eliminate deaths and injuries. Several mine disasters and serious accidents occurred in the 1980's. These include the Farrell #17 mine explosion in 1980 that killed 5; the Dutch Creek Mine explosion in 1981 that killed 15; the Grundy Mine disaster in 1981 where 13 were killed; the Adkins Mine disaster in 1981, where 8 were killed; the R.F.H. #1 mine disaster in 1982, where 7 were killed; the McClure #1 Mine disaster in 1983, where 7 were killed; the Wilberg Mine disaster in 1984, where 27 were killed; and the Loveridge #22 mine disaster in 1986, where 5 were killed. Numerous mine fires, such as Marianna fire in 1988, occurred in the 1980's.

Numerous explosions occurred, such as the Homer City explosion in 1983 and the Greenwich #1 explosion in 1984. Numerous multiple fatalities such as the Bon Trucking roof fall in 1984, which claimed 4 lives, also occurred in the 1980's.

Obviously, in a short time, I cannot discuss all of these disasters, fires, explosions and tragedies in detail, and I do not intend to. I want to address our concerns with the government and industry response to these tragedies, which--like Farmington and Scotia--are milestones. This response in the 1980's illustrates our disappointment with recent changes in government policy, changes that we believe are backward steps in mine safety, changes that ignore the lessons of the 1969 and 1977 Mine Acts.

In similar disasters during the 1970's, government responded positively. Thus, the 1969 Act followed the Farmington disaster, the improvements via the 1988 Mine Act followed the Scotia Mine disasters and the Sunshine Mine disaster, among others.

The 1980's were different, very different. They started with the Patco strike. What does this strike have to do with the mining industry or with health and safety? Let me explain.

The Patco strike was an occupational health strike. The issue was stress on the job. It was well documented and well studied by reputable scientists. Patco presented clear and well-reasoned proposals to the FAA, the government agency responsible. None of this mattered. The facts did not matter. When the government failed to act, the workers reacted and, when they did, the government responded with no sympathy.

The attitude toward the Patco Air Controllers became the attitude toward the miners. Just look at the milestones in coal mining during that era. The winter of 1981-1982 was brutal. In explosions at three different mines, a total of 36 miners died. It was apparent that attention to explosions--the best-understood hazard in the mining industry--was faltering.

What was the government's response? What it did do was bizarre. Barely three weeks after the last of these explosions, the newly-appointed Assistant Secretary admonished his own field staff not to indulge in nit-picking violations. He advised them not to look behind every door and under every rock and told the inspectors to be more cooperative and less adversarial. As with the Patco strike, the facts seemed irrelevant.

Again, the epilogue is noteworthy. Recently, the tenth circuit court of appeals held that MSHA could be held liable for negligence, that is, for not conducting thorough inspections, at one of the three mines that exploded in 1981. The agency is now being sued by one of the widows.

McClure, 1983: another one of those milestones. Seven miners died as the result of an explosion that occurred when ventilation was short-circuited, contrary to the law, when one section was cut into another in a rush to develop a longwall panel. This allowed an explosive concentration of methane to accumulate. Ventilation--the well-known life's blood of any mine--failed in a clear breakdown of fundamental mining practices. Workplace examinations were not properly made to detect the conditions created. There were numerous violations documented before this explosion and many more after. Enforcement was lax. The federal agency had issued ineffective fines for violations cited prior to the explosion, and respect for the law was lost. The

very reason for the success of the 1969 Act was ignored. When the smoke cleared, the operator was fined a paltry $47,500 by MSHA.

The response of the state mining agency here in the state of Virginia was more astounding and highlights the need for a strong federal agency. The operator was fined nothing. The state certifies mine foremen for their competence, a competence that we depend on for our lives, a competence that clearly failed at McClure. The state has the authority to revoke foremens' papers and has authority to impose criminal sanctions against mine operators. No one was decertified, no one went to jail for the loss of the seven lives and no fines were collected by the state.

During our investigations, we also found that the head of the State Department of Mines previously held a top management position at the McClure mine, and at the time of the disaster held a substantial amount of stock in the company that operated McClure, whose parent company was Pittston. We asked the state government to take action. The appearance of impropriety was more than vivid--state law prohibited state mine inspectors from holding stock in coal companies. Despite this, the state exonerated the state enforcement official and, as noted, no action was taken against Pittston Coal Company or their officials.

As a side note, we cannot help but notice the difference in justice applied when it comes to a labor dispute between the miners, the United Mine Workers of America, and that same company--the Pittston Coal Corporation. Millions of dollars of fines and jail have been the responses that the miners and the UMWA received from the same government that did virtually nothing to Pittston and its management following the McClure explosion, which killed seven miners. Are miners engaged in such acts as peacefully sitting on the road committing a far greater crime than mine operators violating health and safety laws, exploding coal mines, and killing miners? Those miners sat down in the road to protect their jobs and the welfare of their fathers and families--some who worked at the McClure mine. Is this equal justice? I don't think so. When miners demonstrate to protect their livelihood, they are tagged as criminals; when coal mine operators blow up coal mines and kill coal miners, they are treated as the elite.

Let me move on to Wilberg, 1984. Twenty-seven miners died when they were trapped by a fire in a mine, rushing to set a production record.

Why were these miners trapped? The operator had been allowed to develop the longwall with two entries, instead of a sufficient number to provide ventilation according to the law and necessary for miners to escape through. The operator was given waivers by the government, absent legal authority to do so, to mine with a critical escape route blocked off. In a rush to produce and with MSHA's acquiescence, entries on one side of the panel had been allowed to deteriorate, rendering them impassable. When smoke filled the entries on the other side of the panel, there was no escape---and 27 miners perished.

What was the government's response? Let us brush aside as a petty and small-minded insult the accusation that arson was to blame for this disaster, which was nothing more than one of the smoke screens concocted during the investigation. Rather, let us look at subsequent actions. First, the agency narrowly focused the investigation into the tragedy on what caused the fire, refusing to address the other, more important issues of why the miners were unable to escape. Instead of

banning, or finding an engineering solution to, the so-called two-entry mining practiced at Wilberg and which MSHA embraced prior to the disaster, the agency quickly sought ways to "band aid" the system to let it continue. Even then, the band-aid approach was not followed. The agency approved plans for other systems that did not contain protections that their experts said were necessary. One such protection involved keeping the tailgate escape route open. It must be noted that the miners' major complaint with the agency was one of making the operator comply with the law, but the agency would not. Although several violations of the law were uncovered during the Wilberg investigation, the agency fined the company a mere $111,000 for the 27 miners' deaths.

The agency's interest, or lack thereof, in enforcing the law is apparent. Nearly five years later, and the criminal prosecutions of those management personnel responsible are still unresolved, and the statute of limitations is about to run out.

The tools Congress gave MSHA, and intended that they use, are ignored. The focus and intent Congress gave in passing the 1969 and 1977 Mine Acts was not to be found with respect to MSHA in the aftermath of the Wilberg mine disaster. They were more interested in diverting attention and accommodating the operators' use of a mining system than they were in forcing out the safer mining systems Congress wanted to be utilized through the Mine Act. They were not interested in punishing those that ran unsafe mines like the Wilberg mine that claimed 27 lives.

The Marianna Mine fire of 1988 also points out an agency failure to examine mining practices with the focus of identifying faulty mining systems and forcing changes to protect miners. The Marianna Mine, located in Pennsylvania, is one of the oldest in the nation. Around 1987 the operator changed its ventilation system and began to use belt air to ventilate the face at high velocities, a practice Congress sought to prohibit in the Mine Act. Atmospheric monitoring systems were installed and, we are told, velocities on the belt approached 1,000 FPM. A belt fire, which is not a rare occurrence, broke out. Miners at the face smelled smoke. Trusting their instincts rather than microchips that constantly malfunctioned, 27 miners donned their self-contained self rescuers and barely, but fortunately, escaped with their lives. The mine remains sealed, and the community that depended on it for its sustenance is destitute.

Our investigation disclosed that the monitoring system at the mine had serious malfunction-related problems and that the high velocities in the belt entry caused the fire to propagate quickly. We found that Congress' concern with fires in belt entries--the need to divert air away from working faces and the need to keep the air velocities low to prevent fast propagation of fires--was well founded. When we look at the agency's role, we found that they were more concerned with defending the mining systems having high velocities of air at the face than they were with examining the disastrous effects of this type of system.

This case was similar to that at Wilberg. MSHA had promoted a system that failed. In both of these cases, the mine operator was using mining systems Congress believed were substandard in the passage of the 1969 Mine Act.

In both of these cases--Wilberg and Marianna--what the coal miners expressed much of their outrage about was the federal agency allowing operators to utilize mining

systems that Congress did not want to be utilized because they did not meet necessary safety and health standards. What coal miners want is for the law to be enforced and improved upon when it falls--not for failed systems which are substandard to replace systems that the law requires.

There are those that are offended by these remarks and offended by the outrage expressed by coal miners. On behalf of those miners, I can only tell you this--you had better get prepared to be more greatly offended. What's needed is to get back to the basics that created the 1969 and 1977 Mine Acts.

There are numerous other milestones I could mention but I think you can see the drift of my comments.

The twenty years of history since the Mine Act can be divided into two ten-year periods, the 1970's and the 1980's. Although the average number of deaths in the 1980's fell to an average of 97 a year, it does not tell the full story of the 1980's. Responses to milestones in these two periods --the 1970's and the 1980's--are as different as night and day. In the first ten years, tragedies were followed by action in order to prevent recurrences; in the second, practices that contributed to tragedies were ignored.

In the first ten years, the administration was attempting to live up to Congressional commitment to place the health and safety of miners first; in the second, the administration was busy trying to get the Mine Act "off the backs" of mine operators. In the first ten years, it could be easily demonstrated that regulation worked, that it consistently reduced the risk of fatal injuries and reduced exposure to respirable dust; in the second ten years, regulations that worked when enforced were targeted to be cast aside.

I want to address those aspects.

In the early 1980's, actions were undertaken to dismantle key parts of the Mine Act which would weaken its very foundation. In 1981, attempts were made to dramatically reduce the MSHA personnel charged with enforcing the law. They sought to eliminate at one shot 500 agency personnel--and that could have crippled the agency. These attempts were met with stiff resistance from coal miners and others concerned with the agency's effectiveness. That plan was blocked. It was not the last attempt to cut personnel, however; constantly throughout the 1980's, such reductions were attempted.

In 1981 and 1982, policy changes and new regulations caused a dramatic effect to occur in mine-site enforcement. Respect for the law was almost entirely lost. In 1981 a new policy was issued on violations that were to be cited as significant and substantial (S & S). That policy caused this type of violation to fall dramatically from approximately 80% in 1980 to less than 24% in the third quarter of 1983.

Simultaneously, new regulations were put into effect by MSHA which created a new minimum penalty of only $20.00. Coal operators soon had little fear of invoking heavy fines. The new $20.00 penalty was tied generally with the new policy on S & S violations--like the S & S rate, the amount of fines fell dramatically. In 1980, mine operators were fined $19,512,943. By 1983 that fell to $6,422,000. Life-threatening conditions were soon cited as non-S & S violations and, instead of operators facing up to $10,000 for each violation, they soon became comfortable with the new $20.00-a-shot fines.

Miners had to again revolt in order to force MSHA to do what Congress directed them to do--to put respect back into the law.

As a result, according to last year's figures, the S & S rate has risen back to approximately 70% and the fines issued last year have risen back to $14,401,875.

In 1982, MSHA issued notices that they planned to revise all health and safety standards for underground mining. They wanted to eliminate unnecessary record keeping, overburdening regulations, etc.

It was not long before we saw what they were really up to--they wanted to eliminate health and safety protections coal miners had been given in the long hard fight in Congress back in 1969 and in 1977. They wanted to turn back the clock to the pre-1969 days. They wanted to do wholesale gutting of ventilation, roof control, electrical, machinery and haulage, fire protection and other standards.

Miners again had to revolt and they again had to take on the industry and the federal agency charged with enforcement of these standards. Congress again got involved and held hearings. Two such hearings were held before the U.S. Senate and focused on the agency's attempts to weaken and eliminate critical health and safety standards designed to protect miners so that mine operator wishes could be accommodated. The agency received bipartisan criticism over their mismanagement of the regulatory process.

That, however, was not enough to put the agency on the right path. Among of the most recent examples of the agency's attempts to gut health and safety standards were the underground mine ventilation regulation proposals. Those regulations, if put into effect, would devastate mine safety. The proposed rule eliminates so many safety protections that it would take me hours to identify each one.

When you look at the milestones of the 1980's, you find events occurring that directly attack the foundation of the Mine Act--that seek as their objective the dismantling of that great legislation, and mostly by the agency charged with its enforcement. The period of the 1980's has had miners constantly revolving against that government agency just to keep that Mine Act intact. Miners were angered by attempts such as the proposed ventilation rules, and at hearings last year turned out in the thousands to protest. Miners again had to take on the government agency charged with protecting their lives. There have been several other actions to dismantle the Mine Act of which I lack the time today to address. Many of these were unfolded before the Senate Labor and Education Committees in March of 1987, and I spoke about them before this very conference in 1988.

Coal miners did not ask to be placed in the position of screaming with outrage over failures to enforce the Mine Act or attempts to dismantle it. They were forced to by those attempting to eliminate the protections Congress gave them in 1969 and in 1977. They had to revolt against the industry to get those protections and they now have to revolt against the agency Congress created to insure those protections to prevent that agency from stealing them away.

In my seven years as head of the United Mine Workers of America Department of Occupational Health and Safety, I have had to spend, in behalf of those miners, the greatest amount of my time stopping the dismantling of the landmark 1969 Mine Act, and I apologize to no one for those actions. If we are

becoming more militant in that defense, it is because we have been forced to. I can assure you of one thing--if attempts to gut the Act continue, our militancy to retain it will increase even more. We know well the milestones of the 1960's and 1970's but we know even better the milestones of the 1980's.

Achievements have been made as a result of the 1969 and 1977 Mine Acts. Death rates, and deaths, injuries and illnesses are declining as a direct result of those, and we are not about to let that slip away.

AWARDS

Award for Coal Mining Health, Safety and Research

Professional Award for Coal Mining Health, Safety and Research

Award for Coal Mining Health, Safety and Research

Gerald L. Baliles, Governor of Virginia since 1986, holds a law degree from the University of Virginia. A recognized expert in the field of environmental law, he served as Attorney General of the Commonwealth before heading a historic ticket in winning the gubernatorial election along with Virginia's first Black Lieutenant Governor and first woman Attorney General. Both as Governor and as Attorney General, Gerald Baliles has been a consistent and staunch advocate of mine safety. During his administration as Governor, he has supported the continued funding of Virginia's nationally recognized mine safety program targeting small underground coal mines, and the computerization of mine safety information managed by the Department of Mines, Minerals and Energy. Virginia's Mine Safety Program, which was originally funded jointly by MSHA and the Commonwealth, is now totally funded by the State and reaches an average of over 3,000 miners at approximately 180 small underground mines each month. In addition, the program also provides Federally required annual refresher training to over 5,000 underground coal miners each year. Through a variety of promotional activities, the program also enjoys substantial community involvement and support. By continuing these initiatives, Virginia has recently met the challenge to provide for worker education and safety in its coal mines. It is, therefore, the unwavering commitment of Governor Baliles to the miner's right to a safe work environment, and to the safe and environmentally sound development of Virginia's coal resources, that has moved the Twentieth Annual Institute to present him with this Award for Coal Mine Health, Safety and Research.

Professional Award for Coal Mining Health, Safety and Research

Murray Jacobson served the Bureau of Mines, U.S. Department of the Interior, in a number of capacities between 1948 and his retirement in 1987. Concluding his graduate work at the Carnegie Institute of Technology in Pittsburgh, he assumed the position of Engineer-Physicist, Branch of Dust Explosions, at the Bureau's facility in Bruceton, Pennsylvania. Following this assignment he functioned as Laboratory Chief for both the Bureau's Dust Explosions Research Station and the Health and Safety Research and Testing Center, where he later served as Staff Physicist and then as Project Coordinator for Health Research. His tenure as Chief of the Pittsburgh Field Health Group was followed in 1971 by his appointment as Chief, Division of Health, Coal Mine Health and Safety, in 1973 as Senior Director of Technical Support, Mining Enforcement and Safety Administration, and finally, in 1978, as Assistant Director for Health, Technical Support, Mining Safety and Health Administration.

As a manager of health programs, he formulated and implemented many major health projects in the areas of dust, noise, radiological hazards, contaminant measure and control, and particulate analysis. He also developed health criteria for and guidance to field health groups, and is the author of an extensive number of publications concerning the health hazards of respirable dust.

The Twentieth Annual Institute recognized Murray Jacobson for these contributions with the Professional Award for Coal Mining Health, Safety and Research.

LUNCHEON SESSION

Gerald L. Baliles Governor of the Commonwealth of Virginia, Richmond, Virginia

"Remarks"

REMARKS

The Remarks of
THE HONORABLE GERALD L. BALILES
GOVERNOR OF THE COMMONWEALTH OF VIRGINIA

20th Annual Institute
on Coal Mining Health, Safety and Research
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Virginia Polytechnic Institute & State University
Blacksburg, Virginia

President McComas, Professor Karmis, ladies and gentlemen, I am very grateful to be the recipient of this award today, though the accomplishments it represents, as you well know, credit the efforts of many, many people.

The coal industry does depend greatly upon the willingness and ability of its components to work together harmoniously. This award shows that we are capable of doing that and should offer some hope that we may do so again in the future--which is part of my message to you today.

I appreciate the opportunity to speak this afternoon--and I thank you for the invitation.

This conference, which has been annually convened for two decades, has repeatedly brought together at Virginia Tech, one of the nation's great universities, some of the most knowledgeable and experienced figures in the international coal industry. Judging from the roster of participants for this year's gathering, you have attracted a distinguished gathering once again. As a result, I suspect that this audience has had more than its share of compelling data and attention-grabbing statistic--so it is not my intention, today, to add to the collection.

After all, you know what a statistician is: That's somebody who says that if your head is in the oven and your feet are in the refrigerator, the middle of you, on average, will be okay.

Along the same lines, I have always been sympathetic to the poor fellow who drowned in the river that was, on average, only six inches deep.

Numbers are helpful for identifying trends, but true insights into the greater meaning of it all are a little shorter in supply.

I make no pretense to having all the answers, but I would like to step back and attempt to take the broader view of our prospects in an increasingly competitive world. I wish to say a few things about the present difficulties in the coal fields, as well.

On that score, as part of my own continuing search for understanding, I picked up a book recently called Zen to Go, a compilation of bite-sized bits of wisdom from Buddha to Yogi Berra.

In this book, which I recommend to anyone pressed by the complexities of the day, the late literary critic Gertrude Stein is quoted as responding to a difficult question by saying, "There ain't no answer. There ain't going to be any answer. There has never been an answer. That's the answer."

Of course, there are those times when we are surely tempted to respond in the same way. Some problems do seem intractable. Yet, we must look for answers even when they are most elusive.

In today's world, there are many difficult challenges, not the least of which is imposed by the compelling need to impress our citizens with the realities of our own economic era--and the nature of the future we face. As many of you know, from the commencement of this administration, I have taken to stage, podium and pulpit to stress the fact that Virginia--and America, as well--has lost its economic insularity. Where once Virginia's economic borders touched only neighboring states, they now reach to Brussels and Brazil, Austria and Australia.

Like it or not, we are part and parcel of a global economic arena, where markets never close and the competition never quits.

Accordingly--and perhaps as never before--when it comes to trading with the world, we are pressed to do more than complacently wait for customers to find us. Rather, we are obliged to aggressively enter every market we can reach with all the imagination and resolve we can summon. In short, we must meet a new age with refined skills in the oldest art: the art of selling. We must learn how to compete again, to hustle for business--and, to do so successfully, we must act creatively.

Fortunately, in Virginia, we have the ingenuity, the resources and the geography to prosper in an international economy. Nowhere nowhere is that more evident than in Virginia's coal industry. Here we have a critically important product to sell--in abundance--with overseas potential for developing markets. We have confirmed that potential during repeated overseas trade missions, and in discussion after discussion, at the highest levels, we have encountered a growing interest.

Developing nations such as Egypt and Turkey are looking for alternative sources of energy. That's why they are interested in coal. Established industrial nations, such as those in Europe, rightly question the reliability of oil. They need to ensure steady sources of energy. That's why they are interested in coal.

As for availability, the only dispute about America's coal reserves is how many centuries-worth we have left. The United States holds coal reserves that approximate the energy equivalent of roughly half the world's oil. Of course, however, there is competition. There are other suppliers--in Australia, South Africa, Poland and China--and, the geographic distribution of coal in the world means that the competition will remain international.

Why, then, buy America's coal? Or, to be more specific, why buy Virginia coal? What advantage do we have over other suppliers? How can we take those advantages and build upon them?

First of all, the state of Virginia does not sell coal. Private industry does.

However, Virginia state government can play a vital role in many respects. To begin with, we can invest in infrastructure, to ensure that the price of our coal is

not driven up by the expense of transportation. In fact, in 1986 Virginia put in place the most ambitious transportation program in its history. In order to create an integrated, multi-model system of road, rail, sea and air, the legislature established a 12-year, $12 billion transportation construction fund. This has already made a great difference. Better roads for Virginia means greater efficiency for industry, whether it is the coal industry or any other enterprise that moves products from the source of supply to the point of demand.

Likewise, we have invested in doing more than keeping our ports in step. We have acted to make Virginia's ports the most attractive on the East Coast--and we have done so by installing patented loading equipment, by digging deeper channels and by fostering cooperative relations between labor and management. Indeed, it has been the attitude, commitment and support of the International Longshoremen's Association that has helped to make the Ports of Hampton Roads the fastest-growing export center in America.

With transportation and port improvements, then, the state can play an important role in supporting the coal industry. However, the state can contribute in other ways, too. As has been done in recent years, state government--through the Governor's Office, the Department of Economic Development, the Department of World Trade and the Virginia Port Authority--can carry the story of Virginia coal to potential overseas buyers. For instance, in Europe, where the environmental movement has become a major political force, much as in America, we can show that Virginia's coal has a natural advantage.

We can tell buyers that higher powers of the universe were good to us. Virginia coal, with its one-to-two percent sulfur content, is clean and plentiful. Further, we can show buyers our commitment to coal research. The Department of Mining and Minerals Engineering here at Virginia Tech is one of the oldest and most well-regarded engineering departments in the nation. The Department is recognized for its research accomplishments and is the home to two internationally known research centers, the only such centers in the nation.

The Generic Mineral Technology Center for Mine Systems Design and Ground Control--which sounds to me like something NASA should be running--has Virginia Tech as the leading institution among the six participating universities in this joint effort to study the design, control, health, safety and economics of the coal industry.

The second center, the Virginia Center for Coal and Minerals Processing, is funded through Virginia's Center for Innovative Technology. It was established last year to provide critically needed research to promote new minerals technology, promote their commercial application and to train technical personnel for the coal and minerals industries. The Center is performing research in coal cleaning, fine particle processing, process simulation and modeling, and automation and control. Nature gave Virginia clean coal; but research can make it cleaner. Here at Tech an advanced coal-cleaning technology has been developed for the production of ultra-clean coal that contains less than eight-tenths of one percent ash and very little sulfur. With this technology, we have the chance to substitute coal for oil and gas and thereby open new markets for Virginia coal.

Infrastructure, marketing and research--these are areas in which we can invest to make Virginia coal more competitive. There is,

however, an equally important issue that demands our constant attention and support: safety.

Coal mining is the nation's most dangerous occupation--and in Virginia, we recognize that reality. Unfortunately, between 1980 and 1986 the state averaged 80 percent more fatalities per man hour than the nation as a whole. Reason: The state's predominant number of underground operations harbor the worst conditions for roof falls, the number one killer underground.

I endorse the improved reporting procedures now active at Virginia's mines. They have given us a far more accurate picture of the number of accidents and the days lost. When accidents occur, the cost in human life and injury are incalculable--and, if no more than a single miner in a single year perishes, it is too many.

That is why we have worked so hard--state, industry, and miners together--to find answers and improve conditions. We created the Virginia Mine Safety Program in 1985 to increase safety awareness among miners at small operations. Initially supported with federal funds, the state took over full funding in 1986 and has expanded the program to include training for miners at larger mines. Today, the program serves about 3,000 individual miners every month. Moreover, from 1986 to the present, it has provided technical expertise in roof control, ventilation and mine electricity in the course of more than 700 site visits per year.

In addition, the Virginia Department of Mines, Minerals and Energy has upgraded monitoring and detection equipment used for health and safety checks. Also, a far greater emphasis has been placed on mine safety and health training in recent years. Will all of this help make the mines safer? I certainly hope so. There are positive signs. For the mines participating in Virginia's safety program, from 1987 to 1988, the number of work days lost due to accidents and injury dropped from more than 4,400 to less than 1,500.

Again, however, although the trend is favorable the numbers are still too high. We are therefore committed to finding ways to do more--and to do it better.

This is necessary not only for the safety and well-being of the miners, but also for the sake of keeping the industry competitive. Every man-hour lost to an avoidable injury is a blow to productivity.

Infrastructure, marketing, research and, most important of all, safety --these are roles for state government. In each, Virginia, by working with miners and industry alike, has played an active, assertive and affirmative role. I am convinced that the coal industry is in a better position today because of that. There are, however some things that state government cannot do, and there are some roles that state government cannot play. This brings me to the present situation: The ongoing labor dispute between Pittston and the UMWA.

The role of state government is not that of an arbitrator; it has no such authority. The state cannot pick and choose among points of disagreement between labor and management. There is, though, is a role for the state in urging and encouraging the parties--face to face--to settle their differences at the bargaining table. I have urged both parties to take advantage of the federal mediation process to find a resolution to their differences--and I do so again today. The process exists for that purpose.

There is no doubt in my mind that Pittston and the UMWA could end

this strike now if they would approach the bargaining table with less intransigence.

There is another role for state government: To ensure that order and peace be maintained--and they will be. Some have interpreted my position as an endorsement of management's position. Others have said that I have acted to protect the right-to-work law. They miss the point. In my role, it makes no difference whether the setting is a coalfield or the seashore, whether it is a city street or a rural lane; when someone picks up a rock and throws it at another, or shoots at a vehicle or into a house, it is violence and it cannot be condoned. A society cannot function when a group or even a single individual presumes to justify violence by the sincerity of its views.

I do not doubt for a minute that Pittston or the striking coal miners profoundly believe in their position--and, so long as they remain peaceful, I will be the first to defend either party's right to be heard. Personally, I do not feel that either party has a monopoly on truth or virtue in this matter. Indeed it seems to me, as this dispute has drawn out, that neither party has adequately considered the interests of the quarter of a million people in Southwest Virginia--most of whom have no interest in this dispute other than the detrimental effect that it has on their livelihood. This strike is a tragedy, if for no other reason than the damage it has done to the economic progress we have made.

In recent years, more than 100 million dollars have been invested by the state in Southwest Virginia with the intent of buttressing the economy and attracting diversified industry. Those funds have gone to public education, transportation, industrial parks, housing loan programs, agricultural marketing, workplace safety, solid waste management, state parks and soil management. As a result, we are seeing evidence of a more diverse, more optimistic economy in Southwest Virginia. From 1986 to 1988, more than 30 new manufacturing facilities were established in Southwest Virginia, and 27 existing manufacturing facilities expanded their operations. Together, those developments created nearly 6,000 new jobs and brought in investments exceeding $180 million--all for Southwest Virginia.

We are, then, moving ahead and confirming what state government can do to establish and sustain a healthy economy. The fact that it was announced yesterday that Virginia enjoys the lowest unemployment level in sixteen years suggests that we are doing something right. Government, though, no matter how dedicated, can accomplish little unless the people themselves--those who labor and those who manage--are willing to unify in the name of progress and common prosperity. With this in mind, I say again to Pittston and the UMWA: Remember Southwest Virginia. Go back to the bargaining table and settle the strike.

I remain fully committed to improving Virginia's economic position generally and in the coal counties specifically. While there are enormous challenges in an international economy, there are just as many opportunities. In the case of the coal industry, we have seen the difference we can make. Investments in infrastructure mean more efficient transportation; investments in marketing mean new buyers; investments in research mean a more flexible, more adaptive industry; and investments in safety mean more secure working conditions and greater productivity.

John Gardner once wrote that "life never was series of easy victories. We can't win every round or arrive at a neat solution to

every problem. But a driving, creative effort to solve problems is the breath of life, for a civilization or an individual." That must be the spirit that inspires our actions today. We must make the most of what we have been given and not fail to find accord. There is simply no way--I say again, <u>there is no way</u>--that we can harness the future and advance this Commonwealth, or this nation, unless we work at it together.

TECHNICAL SESSION ONE:
HEALTH AND SAFETY PROGRAMS:
EVOLUTION THROUGH TECHNOLOGY

Chairmen:

James Corsaro
General Manager of WESCAR, Inc.
Carbon Industries, Inc.
Charleston, West Virginia

McDonald Hagy
Manager of Safety
Island Creek Coal Company
Oakwood, Virginia

THE PEOPLE SIDE OF THE EVOLUTION IN SAFETY PROGRAMMING

John Caylor

Manager Safety & Health

Cyprus Coal Company

The meanings of the words safety, accident prevention, and loss control are concepts which certainly have been evolutionary. These concepts are still changing today, and they continue to change as our economy changes, as management style changes, as our base of knowledge changes, as we become more professional in our approach to Safety and Health issues, and as technology changes - and we are certainly in the midst of rapid technological change in the mining industry..

One of the earliest records of the concept of accident prevention is the Bible, in the book of Ecclesiastes.

> "If you dig a pit, you fall in it; if you break through a wall, a snake bites you. If you work in a stone quarry, you get hurt by stones. If you split wood, you get hurt doing it. If your axe is dull and you don't sharpen it, you have to work harder to use it. It is smarter to plan ahead." - Ecclesiastes 10:8-10

The implication here is that some planning is required in order to avoid these pitfalls. Over the years the planning process for anticipating these pitfalls, or areas which have the potential for the occurrence of the unwanted event, has been the evolutionary aspect of safety programming and loss control.

The early 1900's in this country marked the first progress made in safety. There were no workers' compensation laws until around 1911 - there was simply no financial incentive for management to be concerned with preventive measures. They just found another warm body. Charles Dickens' novel Hard Times is a story about life in nineteenth century industrial England which reflects this kind of thinking. In his novel there is a character named Mr. Bounderby who owns a mill in a grimy, monotonous little town somewhere in the midlands. The work is tedious and dehumanizing, the pay is inexcusable, the physical environment is filthy and unhealthy. Mr. Bounderby is understandably defensive about it. I'll quote an excerpt for you.

> "Now you have heard alot about the work in our mills, no doubt you have? Very good. I'll state the fact of it to you. It's the pleasantest work there is, and it's the lightest work there is, and it's the best-paid work there is. More than that, we couldn't improve the mills themselves, unless we laid down turkey carpet on the floors, which we're not agoing to do."

Mr. Bounderby is given to pronouncements about the needs and ambitions of the mill workers.

> "There is not a hand in this town, sir, man, woman or child, but has

one ultimate object in life, that object is, to be fed on turtle soup and venison with a golden spoon. Now they're never agoing to be fed on turtle soup and venison with a gold spoon."

Early in this century, in which physical conditions represented the area almost all progress was made in safety. Because of the deplorable conditions, considerable progress was made. In 1912, for example, it is estimated that 18,000 to 21,500 thousand workers were killed. In 1933 those estimates were reduced to around 14,500.

In 1931, H. W. Heinrich, who many considered to be the father of Safety Management and Loss Control, published his book Industrial Accident Prevention. This book still serves as the basis for much of our philosophy in the control and prevention of accidents today. Our safety philosophy, however, has not kept the pace with the evolutionary changes in the work force that have taken place since the 1930's.

I want to discuss with you today safety management changes, and also changes in management styles that reflect the thinking of management regarding workers. From the early 1930's through the early 1950's we were in an unsafe act and unsafe condition era. Some of us, particularly in mining, are still there today. Heinrich's book espoused the philosophy that most acts are caused by unsafe conditions. He stated that his research indicated that 88% of all accidents were caused by unsafe acts and the remaining 12% were caused by unsafe conditions or acts of God. Other studies since that time support his position.

The 1950's and 1960's began the period during which the term Safety Management became known. We will call this the safety management era. Safety engineers began to define responsibilities in safety and in setting policies. Management terms and concepts were applied to the problems of preventing accidents. These measures were effective. According to the National Safety Council, frequency rates (which were then based on 1,000,000 man hours worked instead of on the 200,000 man hours used today) were reduced from 15 in 1931 to 6 in 1961. Severity rates dropped from 1,590 to 666 during the same period. However, from the early 1960's to the early 1980's, frequency rates continued to make some improvement.

In 1969 we got the Coal Mine Safety and Health Act and, in 1970, the Occupational Safety and Health Act. We also got job security. Suddenly, safety issues became important to management. Some will call this the OSHA era, or for us here, the MSHA era.

I was a beneficiary of that, as were many of you. Safety became a discipline in its own right. In the early 1970's when I first got involved in safety, there were less than a dozen schools offering undergraduate degrees in safety. Today there are well over one hundred.

MSHA and OSHA both brought about new role definitions for the safety professional. Most of our energies were focused toward sorting out the new laws and how they related to operational safety issues. Much of our energy was focused on compliance. Then we worked through those issues and began to focus on setting objectives and establishing accountability systems. We then entered the accountability era. Some organizations have not advanced as much as others, particularly in the mining industry. We run the gambit in safety programming philosophies from Heinrich's theories of unsafe acts and conditions of the 1930's and 40's to quite sophisticated programs which establish objectives, assign responsibility, and establish systems of accountability. Some of this thinking can be capsulized by the following:

ACCIDENTS ARE

I. 1. Loss of Control,

2. Poor Planning,

3. Weak Organization,

4. Ineffective Direction;

II. In direct conflict with the basic objective of the organization;

III. A reflection on the capacity of People at all levels to execute their basic functions;and

IV. Symptoms of operational errors.

The degree to which accidents are controlled is a measure of - OPERATIONAL EFFECTIVENESS, AND MANAGERIAL CAPABILITY.

In the Safety and Health Policy statement of my company, many of these concepts of responsibility and accountability are espoused.

CYPRUS COAL COMPANY
SAFETY AND HEALTH POLICY STATEMENT

It is the policy of Cyprus Coal to provide and maintain safe and healthful working conditions, and to follow operating practices that result in an improved safety-and health-related environment for its employees. Safety standards, both internal and external, will be observed in all operations.

We hold every manager, every supervisor, and all staff members accountable for exercising their professional management skills in every reasonable, practical, and timely way in order to eliminate hazards and to prevent injury to the work force in their charge.

We hold every employee accountable for following all prescribed safe work practices and procedures. No job will be considered so urgent--no schedule will be considered so rigid--that the time cannot be taken to perform the job in a safe manner.

Safety and health personnel will provide accident and hazard analysis, evaluate the status of on-going safety programs, and submit to management appropriate recommendations for improving worker and operational safety.

Safety must be considered an integral part of every activity in the organization. Management policy is that the prevention of losses in the workplace is to be treated as any other managerial function. Every manager and supervisor must embrace his or her responsibility for achieving organizational goals in the reduction of accidents, thus obtaining production at minimal cost.

No company or mine will be considered properly managed regardless of its proficiency in other management areas unless it maintains an acceptable level of safety performance.

We now come to the current era of safety programming which is the era of human behavior, and which began in the early 1980's. This is the era that I would like to focus on today. As the title of my presentation today indicates, it is the era of"the people side of the evolution in Safety Programming." Safety is now, in my view, an issue of how we relate to the worker. The tremendous strides taken and improvements made since the early 1900's through 1980 will not continue to improve significantly,in my view, particularly in mining. Too many of our resources are taken up with compliance issues. The 1969 Coal Mine Safety Act and subsequent 1977 Mine Safety and Health Act focus primarily on workplace conditions. This is a step back to the 1930's Heinrich philosophy of unsafe acts constituting 88% of the injuries, and unsafe conditions contributing only 12%. Sadly enough - safety laws focus on the 12% - the unsafe conditions. All of our resources are focused on this.

Don't misinterpret what I'm saying. The nature of mining is such that workplace conditions must receive the attention they deserve. The Mine Act and its statutes, however, do not necessarily lend themselves to the proper discrimination of what is important to workplace safety and what is not. As a result, an inordinate amount of resources are focused on correcting problems in ways that do not have an offsetting impact on improving performance or reducing accidents. This is the current frustration of many professionals today. If you are not having that frustration, then the name of your safety program and loss prevention efforts is compliance..

I've made some fairly brash statements, in some of your minds, I'm sure. I would like to explore these ideas further with you, by focusing on changes in management styles and management philosophy since the 1930's. I'm going to suggest that our current attitudes toward safety programming has not kept pace with these changes.

Until the mid 50's, management thought favored what was called the classic school of management. This school was governed by rules of bureaucracy and favored job descriptions, standards of performance, writing corporate manuals, determining rules and regulations to govern worker behavior, and the assumption that people were basically all alike -- they will behave as management dictates and will react to management's schemes, wage incentives, etc.

The classic school of thought was replaced by the human relations school, which said that behavior is dependent upon happiness. A happy worker will be a productive worker and do what management wants. In this school, management's task was perceived as ensuring that the employee was psychologically comfortable on the job. This was based on the assumption that "all people are alike"-- happy folks are productive folks.

In the 70's the contingency school of management thinking emerged-- and was perhaps more in tune with reality: people are different; therefore how we deal with a worker must be contingent upon the situation, on the worker, and on his needs.

As our individual organizations shift from one school of thought to another, we must make sure that our safety programs shift in accordance with the current management approaches and styles. Too often safety programs have remained rooted in the classical school of thought, depending upon standards of managerial performance, corporate safety rules, and rules and regulations for getting the job done. While this is appropriate to 1950's style management,it is inappropriate to the 1990's style of thinking in management. We must assess our organizational management school of thought and build a safety program that will be in tune with it. Regardless of where our organizations happen to be, we need to be cognizant of what motivates the people we work with.

A psychologist that you have all heard of--some of you I'm sure have studied his theories--in 1954 published a theory of motivation centering on a hierarchy of needs, a term which has by now become part of the standard vocabulary for behavioral scientists and even managers. His name was Maslow.

At the bottom of Maslow's hierarchy are the physiological needs (food, water, warmth, sex, etc.) Once these needs are fulfilled the worker is no longer motivated by them, but moves off to the next level of importance, the safety or security needs. (This includes both literal physical safety, and the feeling of being protected against future injury or financial hardship).

When these needs are fulfilled, and only then, the motivational effects of the higher-order needs--love, belonging, and esteem --come into play. At the very top of the hierarchy is self-actualization, that is,a person wanting to contribute to do things that he or she is capable of doing.

If Maslow's theory is right--and there is considerable evidence that it is- -modern affluence has dratsically reduced the lower-and middle-level needs as motivators. Behavioral scientists have recognized for some time now that a concentration on economic and security incentives can produce only limited gains in worker productivity. That is not to say that physical and economic well-being are not still necessary ingredients in job satisfaction; they are. Nor will anyone claim that employees cannot be motivated by the hope of higher salaries: obviously they can. But research indicates that, for the long-term, the most you can do by satisfying the lower-order and middle-level needs--and nothing else--is to produce a neutral attitude toward the job. We might also call this ambivalence.

Increased affluence is not, however, the only significant difference between today's work force and yesterday's. There have been striking changes in the last 10-20 years in the degree to which workers are willing to rely on authority figures and to accept authoritarian styles of management. Part of the reason is simply that today's workers have more formal education than their predecessors, especially those in the 20-34 age group. It is not at all uncommon to find educational histories that include 1-2 and even 4 years of college experience. This doesn't mean, necessarily,that we have <u>smarter workers</u>, but it does mean that workers' perceptions of themselves have changed and that they are much less likely to put up with a supervisory style that treats them as if they are ignorant.

The public school system and the college system today places students in an atmosphere in which value is placed on debate, discussion, questioning and exploration. Workers coming from that kind of environment are much more likely to ask <u>why</u> an assigned task has to be performed in one certain way and no other. If a supervisor of "the old school" tells such an employee to "just do your job, and leave the whys to me," what has he done to that relationship? Likewise, condescension won't work; the"strong, silent" approach won't work; the verbal "bottom beating" won't work. Taken as a whole, the work force of today is simply not going to be "whipped into line." Hostility and rebelliousness are the natural offspring of this type of management style.

But hostility, rebelliousness, and subversion are not the real enemies--these are easily recognizable. The greater enemies are the more insidious types of problems such as apathy, unresponsiveness, and a merely pro forma performance of job duties.

As a result of these changes, including the communications media growth that gives modern day workers a much different perspective of themselves in today's world, and the increased mobility of the modern employee, not to mention unions and mining laws that give employees new

avenues for redressing their personal and collective grievances, the picture begins to come into focus: employees perceptions of their roles vis-a-vis management are changing, and traditional management styles are becoming more and more irrevelant--even counter The greatest potential for improvement in safety and productivity is in the human area. Are we challenging our employees to be involved and perform at some level above the average?

There is a great deal of evidence to suggest that today's workers are seeking autonomy, responsibility, independence, and at a minimum, a leadership style that implicitly recognizes the workers capacity for autonomy and responsibility.

How does all of this relate to safety? I firmly believe that our current safety programming is outdated. It does not recognize the changes in worker motivators that we have just discussed. Improved safety performance in the future will require safety programming that recognizes that today's worker will not respond to rules and regulations without having some input into their development.

We should no longer expect that workers will work safely just because we have told them to do so.We must begin to do the kinds of things that make the worker feel a part of the process--not a victim of it. We need to get him involved in the process to the extent that he will accept the responsibility for safety not only for himself, but will encourage his peers to do likewise. Future programs should center around employee participation. Without that they will not buy into the program.

In a major study several years ago, Dr. Rensis Likert found unbelievably high correlations between his defined organizational "climate" and return on investment, profitability and growth. Dr. Likert included these factors as he assessed climate:

1. The amount of confidence and trust between the worker and management. Team relationships clearly achieved the best results. The "me vs. them"relationships achieved the worst results.

   In safety,the latter might mean the "police vs. policed" relationship so commonly found between management and workers in many traditional programs. This climate is counter-productive.
2. Teaching workers to solve their own problems. This was found to be more successful than giving them all the answers.

   How many times has management been better "answer givers" in safety than teachers of how to solve problems?

3. Actively soliciting the ideas and opinions of the worker was extremely important. This is very important in safety. Who is the best expert on safety on the job? Obviously, the worker -- yet we have not tapped that resource.

4. Recognizing accomplishments was also highly important. We need to spend more time giving positive reinforcement for a job done properly.

   Many traditional safety programs are built on negative reinforcement. We lie in the weeds to find the unsafe actor so that we can "zap" him.

This study clearly showed that certain organizational climates are closely connected with organizational success. There is little doubt that a similar connection exists between safety success and climate. Traditional safety programs in today's environment may tend to build an unhealthy climate through policing, through answer giving, through ignoring the ideas of workers, and through a negative approach to safety.

Much of the industry's current safety programming is outdated because it does not recognize these changes in worker motivation. Improved safety performance in the future will depend a great deal on how involved we allow the worker to become in safety programming. Workers should feel like they are part of the process of developing safety rules. Then they are more likely to live by them. Workers should be involved with reviewing safety statistics and analyzing accidents. They are more likely to find solutions to long-term problems. Workers should be more involved in safety inspections and in looking for unsafe acts or conditions. Peer pressure may be a greater motivator than an established procedure.

More employee participation is a key element in enabling companies to become more efficient operations. Management is beginning to recognize that the active participation of all employees is crucial to improving performance and profits. Safety may be the most practical and appropriate place to start. If successful, this can be the catalyst for improving employees' participation in other areas of management as well.

Getting back to our original discussion about an inordinate amount focused on compliance. I think that safety professionals are going to have to live with that. We should, however, not be satisfied with the status quo. We may need to move the compliance area aside to its own niche where management and regulators do not get safety management,and safety programming, confused with compliance. They are not the same, and they have never been the same, although they obviously have common goals. We may have allowed the confusion to exist, but they are not the same.

I will suggest that when we address the issue of worker motivation, employee participation, management style, and safety management systems that compliment the organizational climate, that the compliance side--in this niche over here—will soon begin to take care of itself. I'm saying this while the citations and orders in my company have risen by 200% and inspector days by 33% in the past two years. I have never seen greater regulatory pressure than we are currently facing, but we cannot let that detract us from what we know will produce results.

This simply means that our resources must be redirected. We may need additional resources in order to focus on the areas of employee motivation and participation that we know will be effective. We must communicate to the regulators that,while we recognize they have a job to do; and that it's an important job we have more important issues to address. We must find ways in which they can participate with us, even though their options are limited because laws are written by those who have no experience in management principles. We must, as a profession, do more to influence regulators-- and particularly to include state laws, where the greatest potential for success in making changes may lie.

I challenge each of you in safety management to look critically at where you are spending your resources. If your programs are based on compliance and the outdated era of the three E's, Engineering-Enforcement-Education, you may need to reevaluate what you are doing, and where your resources are being placed.

While I am fairly confident that many here today-perhaps even the majority--will not agree with me in whole or part on what direction our safety programming should take, I hope that I have challenged at least a few of you to at least look critically at what you are doing in advising management to improve their safety performance. For the regulators that are here I hope that I have at least given you a different perspective.

For those of you here representing labor, stop sitrring up the regulatory pot. This will not get the results we all want--improved safety in the work-

place. It will draw resources from where they should be placed, which is in getting workers more involved in workplace safety.

The challenges for all of us are great. Without a cooperative effort, safety results will not continue to improve. We all must collectively focus on the people side of safety programming.

Thank you.

EFFECTIVE LOSS-PREVENTION CONCEPTS: PRESENT AND FUTURE

Philip E. Thomas

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MINING IN THE POWDER RIVER BASIN A BRIEF HISTORY

To understand the challenges and opportunities of surface coal mining in the Powder River Basin of Northeast Wyoming, it is important to visualize the topography. This area of the State consists of high plains, broken by rolling hills and buttes. However, the attractiveness of Campbell County, Wyoming to the coal industry was not the treeless landscape and roaming herds of antelope and mule deer. Instead, it was the shallow overburden overlying vast expanses of low sulfur sub-bituminous coal.

Coal mining began in Wyoming in 1868 at the Carbon Coal Mine. In the Powder River Basin, the present-day Wyodak Resource Development Corportation began mining coal in 1923 as Wyodak Coal Company. Mining was accomplished by the use of horse-drawn scrapers and sluicing; later steam shovels were used to mine the abundant coal seams. Today, modern mining methods are used to provide coal to its Neil Simpson and Wyodak generating stations. Wyodak is the only mine-mouth operation in the basin.

In 1971, AMAX Coal Company began construction of Belle Ayr Mine. The first interstate rail shipment from Belle Ayr was in November of 1972. In response to the 1973-74 Arab oil embargo, expansion of Belle Ayr Mine began. AMAX Coal Company began construction of Belle Ayr's sister mine, Eagle Butte, in 1976, and coal shipment began from Eagle Butte in 1978. By 1988 the combined coal production of Belle Ayr and Eagle Butte Mines exceeded 26 million tons annually.

EFFECTIVE LOSS PREVENTION CONCEPTS

Accomplishments

Over the five-year period 1983-1988, Belle Ayr Mine has worked 4 1/2 million workhours with a lost-time injury rate of only 0.94. In other words, less than 1 percent of the work force experienced a disabling injury during this period. The national lost-time injury rate over this same period for surface coal mines, as measured by M.S.H.A., was 2.84 or approximately three hundred percent higher. What makes this accomplishment even more significant is that Belle Ayr Mine has a young work force, with an

average age of thirty and an average work experience of eight years. However, each employee accepts the premise that experience alone is not enough; what is most important is safe work experience.

I would like to highlight some of the other important accomplishments obtained by the management/employee team at Belle Ayr over this same time period (1983-88). The mine has twice worked over 1 million workhours and 365 days without a lost-time accident. In 1987 the mine earned the prestigious "Sentinels of Safety" award for working over 680 thousand workhours without a lost-time injury. Additionally, many State of Wyoming awards and in-house company recognitions have been received and are proudly displayed at the mine.

The loss-prevention accomplishments of Belle Ayr Mine have not occurred by random chance. They represent commitment and careful planning forming a pattern of success in the loss-prevention areas. These areas include management commitment, employee participation, mine-level loss-prevention efforts and employee recognition.

Management Commitment

Management commitment to loss prevention must be more than just a policy statement in an employee handbook or a set of directives in a policy and procedure manual. Commitment begins with affirming to employees, customers, and the community that safety and production are linked in the foundation of good business practices. Such is the case with AMAX Coal Company and its Western Division mines. Each manager is aware that, excluding the effect on operating cost, there are other consequences of injuries to employees. There is the pain and suffering of the injured employee, the risk of permanent disability and, finally, the economic effect on the employee and his/her family. Our company believes, and each manager realizes, that a reduction in injury experience has an intangible benefit of helping to increase morale and improve employee/management relations, both of which impact on the overall operation. In short, effective loss prevention is inherent in the day-to-day operation. It's not just an item on a yearly performance appraisal.

Financial Support

Financial support by upper management towards the goal of injury- and incident-prevention programs has greatly improved the effectiveness of the overall loss-prevention effort. Examples include: employee training, supervisor training and safety recognition awards. Each of the topics will be highlighted later in this paper.

Employee Participation

The cornerstone of any successful Loss-Prevention Program is the joint cooperation of management and employees working together to meet common goals. However, this ideal is often harder to achieve than to conceptualize. Its attainment begins with the understanding by each employee that safety is his/her personal responsibility. How is this accomplished? It is presented as a matter of fact at new employee orientation and reinforced through safety meetings, positive discipline programs, employee input and individual contacts. Contacts of this type are routinely performed on a formalized basis.

The bottom line is that employees have accepted the concepts of personal responsibility and accountability for their actions. Once this bridge has been crossed,

the door is open to innovative loss prevention concepts and practices.

Mine-Level Loss-Prevention Efforts - What Works And What Doesn't

Every year, every mine conducts annual refresher training programs. At Belle Ayr and Eagle Butte Mines this is viewed as an opportunity to present new twists or insights with respect to mandatory requirements. Many times our training has been conducted as team competition. This has been very successful, with prizes awarded to the team with the best test scores. It is rewarding to watch the miners take and compare notes of each presentation and actively participate in the training.

The soul and substance of annual refresher training is taken from the loss-prevention audit. This audit reflects the injury and incident experience of the mine and gives a clear and concise picture of problem areas. Using the audit to identify these problem safety areas, annual retraining efforts can address specifics. The result of this approach has been a dramatic reduction in injuries and incidents in those targeted areas.

For example, the major type of injury in 1985 was back strain. Back care was incorporated into the annual refresher training early in 1986, and the result was a 50-percent reduction in reported back injuries. Hand-tool incidents were the major types of injury. Each whereas in 1987 slips and falls were the major type of injuries. Each was addressed in annual refresher training with a result of a 90-and 80-percent reduction, respectively.

Supervisor training has been expanded to include more than regulatory requirements. AMAX has made the decision to add several additional training hours to improve supervisor skills in the area of safety. Supervisors have completed the DuPont S.T.O.P. Safety Program for supervisors, as well as in-house programs. The results have been noted by improved injury and incident reporting. Supervisors know that the reporting process is more than a paper exercise. They realize that realistic recommendations are required in order to prevent recurrence.

The yearly loss-prevention audit mentioned previously is a major instrument driving the mine safety effort. Not only does the audit identify the safety experience by category, such as location, job classification, crew, time of day/night and type of injury, but it also identifies unsafe acts and unsafe conditions. Next, the audit provides conclusions and recommendations for improvement. Supervisors have a record of their performance and the performance of their crews. This information is then used as a planning guide to future job preparation and job assignments.

In order to ensure that safe work practices are understood by everyone at the mine site, communications between management and front-line supervisors are passed on to hourly employees. This provides the foundation for the "grass roots" of continued safety awareness. An excellent example of this process is the challenge of achieving continuity of information while operating on a 12-hour rotating schedule. To address this problem, crews meet with their supervisors at the beginning of their shifts after each 7-day-off period. The topics of these meetings include current pit and work-area conditions, as well as general information topics and safety information. Managers from each area provide the supervisors with information to use in their employee meetings. This information is given to supervisors prior to their leaving the mine site for the 7-day-

off period. This method of communication allows the supervisors to have current information to share with their employees. An additional benefit is that employees now more regularly deal directly with their immediate supervisor with respect to concerns or ideas. Problems, concerns and questions are handled by the front-line supervisor, who has the information needed to assist and direct the work force.

This same concept applies to safety. Trial and error has proven that the concept of one "safety man" with all the responsibility for safety will not work. The connotation of one person with all the responsibility for safety will exist in everyone's mind, causing the real responsibility for employee safety to shift from the front-line supervisors, where it belongs, to that single individual. The results of the one person concept will produce such side effects as poor housekeeping, equipment damage, high workers' compensation costs, and, possibly, serious employee injury and illness. Employee safety is a shared responsibility of management and employees. No one individual can assume the entire safety role. How then does the safety manager function effectively in a management structure which traditionally does not consider him/her as a line manager? To be effective, the Loss Prevention Manager does not need specific authority. What matters more is the confidence of the General Mine Manager and support of all other managers of the operation. If these two elements are in place, then the extent of his or her specific authority is not very important. What is important is a working knowledge of hazards, safety principles and techniques, as well as enthusiasm, drive, perseverance and the ability to get along with people. Clearly, he/she must also have the ability to get others to do the work. Safety management carried out tactfully when dealing with other engineers, managers, supervisors and hourly employees works for the benefit of the entire organization.

Recognition

The recognition of employee safety achievement is another important element in effective loss-prevention efforts. In the past, our industry has used incentive programs as a "quick fix" for poor safety performance. At AMAX, emphasis is placed not on incentives but on recognition for individuals, crews, and the total work force in order to reinforce excellent performance. Recognition also provides continuing reminders of safety goals yet to be attained. Each employee is aware that attaining a goal in production or safety is secondary to the individual safety of each employee.

EMPLOYEE PARTICIPATION: PRESENT AND FUTURE

Employees at Belle Ayr Mine have become active participants in the total mining process. Each realizes the impact of his or her personal contribution.

Employees have met the challenge to become more flexible miners. Regularly, they are offered the opportunity to learn new skills. The construction of a fluidized thermal bed coal dryer with associated fire protection and detection systems has required new safety skills. The addition of carbon monoxide monitoring systems for the preparation plant, new drilling and blasting techniques and a batch load-out system which operates from a programmable line computer, along with computerized silo coal blending, has changed many of the job requirements of the traditional miner. Currently, we are experimenting with the development and use of

individualized and self-paced training modules in order to further expand our employees' knowledge with respect to their specific job assignments and safe work practices.

Safety is impacted by technological change as well. New products introduced into the workplace require new methods of sampling for hazards and new forms of respiratory and biological monitoring in order to determine the effectiveness of both the engineering and personal protective equipment used to control employee exposure. Employees must be instructed in engineering, instrumentation, and equipment design and operation in order to work in a safe and healthful manner. In the coal industry today, effective loss prevention is more than an occasional safety talk; it requires a commitment by our employees to acquiring the safety skill necessary for dealing with changing mining methods and meeting future challenges in our industry. We have a commitment as managers to help our employees accept and learn the new technology, and gain the safety expertise necessary to use it.

A FORMULA FOR A SUCCESSFUL SAFETY PROGRAM

By: Raymond A. Bradbury, President and Troy Ed Chafin, Director of Training

MARTIN COUNTY COAL CORPORATION

What is the measure of a successful safety program? Will the same approach work for all companies? Is there one common denominator in preventing injuries associated with mining of coal? How does one avoid or overcome the attitude that may still be prevalent today, that is, "If I work in a coal mine I'm going to get hurt someday"? This notion should have been put behind us years ago.

Ed Chafin and I are simply going to relate to you what has worked for us. Whether or not is is applicable to your own operations you can decide. I know, contrary to what the media and the general public might think, that most coal companies today have successful safety programs in place. You may not see those successes reported on or written about every day, but we in the industry are very much aware of them. The improved performance in the U.S. coal industry last year, with regard to fatal accidents, is one that we can all take pride in. We also know, however, that as long as the industry continues to experience loss of life in coal mines, we still have further improvements to make. I have tried to formulate a catchy phrase or idea that would appropriately apply to what Martin County Coal Corporation is accomplishing in regard to safety on the job. While preparing for this talk today, I've had time to direct my thinking to some important phases of what we have done in order to be successful. I'm not even sure my colleagues would altogether agree with me. They might have other ideas. Nevertheless, I have taken the word ACTION and used that as a word that describes what I think can be applied to our safety program--or to anyone else's, for that matter. Each letter of that word is the first letter of another word that is important to our safety program. Using those words is the way that Ed Chafin and I will attempt to cover what I believe will describe our formula for a successful safety program. The words correctly follow the order of the six letters that spell the word ACTION.

In 3 months I will have completed my 20th year with Martin County Coal. When I went with A.T. Massey to develop that operation in 1969 I was very much aware of coal mine safety. The subject was much in the news in November of 1969, because, you'll recall, the nation was on the verge of seeing the most important and most inclusive piece of federal legislation ever to deal with coal mine safety enacted into law. That bill became the Federal Coal Mine Health and Safety Act of 1969 (Public Law 91-173). Many of us at that time thought we'd never be able to operate our mines within the law and be successful. It did require some adjustments

and it took several years to recover the lost productivity that resulted, but we are a safer industry today, in the final analysis, as well as a more productive one. We have all learned that the two go together, that is, safety and production. Your most productive mines are also your safest mines.

I have used the word AWARENESS a lot over the years in an attempt to pass along a legacy of mine safety that I inherited from my father, Arthur Bradbury. Our workers at Martin County Coal have to be AWARE of how important it is to be safe workers in order to avoid accidents and injury. They have to be AWARE of the fact that conditions can change daily in coal mining operations because they do not work in a static or stationary environment. The physical conditions change and the equipment has to move. Hazards may be introduced that result in the need for an increased AWARENESS. Our foremen must also be AWARE of their great responsibility for promoting, practicing, and expecting safe work in order to fulfill their production goals. More important is the fact that our foremen and their crews are aiming for another accident-free year or the attainment of the next 100,000 employee-hours without a lost-time accident. For this, the crew receives a banner to display at their mine portal or surface mine. We have crews that have exceeded six years and 400,000 employee-hours without a lost time accident.

Another word that I refer to a lot when I talk to anyone about mine safety is COMMITMENT. This is the second letter of our ACTION program. I started work at Martin County Coal Corporation COMMITTED to (1) operating the safest possible coal mines in Kentucky; (2) providing the safest and most productive equipment I could introduce; (3) hiring people from the area and providing them with the training to instill good, safe work habits and the ability to produce; and (4) a pledge that we would achieve a ZERO fatality frequency. Not as an afterthought, I might also say, our company was COMMITTED to be a dependable supplier of high-quality steam coal to its customer, Duke Power Co., while providing a profit to its parent, A.T. Massey Coal Co.

We have met all of the COMMITMENTS but one. Unfortunately, Martin County Coal has experienced ONE FATAL ACCIDENT in over 18 years of production. A roof fall fatality occurred on September 20, 1982 to an experienced miner. The accident investigation found no violations of Title 30, CFR. Our company has compiled the records shown on the accompanying chart in the period dating back to March 15, 1971. The fatal accident Incidence Rate to date is 0.01. We anticipate continued work at Martin County Coal without the loss of life. Working safely requires a state of mind, a COMMITMENT, in order to avoid injury on the job. We do experience non-fatal occurrences with days lost. Our leadership team is COMMITTED to achieving the lowest Incidence Rate possible. In previous years we have had IRs of 2.34 and 2.67. However, under the current MSHA accident reporting guidelines, the best we've done in the past 3 years is 4.47. Martin County Coal has no light-duty workers and returns no one to work until he or she is pronounced by their doctor to be able to work at 100% capacity.

I can't leave this "C" word without mentioning another one that is important in any safety program, and that is COMMUNICATION. No safety program can be successful, in my judgment, without good, effective COMMUNICATION. Martin County Coal has relied on both oral and written COMMUNICATION to convey the message of mine safety. Our Training Office personnel, our mine supervisors and our staff people rely on voice COMMUNICATION in transmitting the idea of accident prevention. Our company uses written COMMUNICATION extensively to keep the subject of safety on our employee's minds. The Training Office uses a Safety Newsletter each month to review the company's safety performance, to review mine accidents, and to bring pertinent safety articles to the attention of our workers. These are placed in pay envelopes and contain 4-

to 6 pages of useful health and safety information. In addition, Martin County Coal publishes a bi-monthly newsletter which goes to all company employees. I write a column titled "The President's Column" in which I review our safety performance, our production performance, and provide some statistical data. These and other COMMUNICATIONS which may be letters or memorandums are circulated or posted on bulletin boards as needed, and are used to encourage and motivate our workers to achieving safer performances.

Probably the most important aspect in developing a safe worker, in my judgment, is TRAINING; thorough TRAINING, innovative TRAINING, TRAINING of current procedures and TRAINING by people COMMITTED to eliminating lost-time injury accidents.

As I pointed out earlier, Martin County Coal came into existence coincidentally with the Coal Mine Health & Safety Act of 1969. Realizing early that we would be hiring a lot of employees with no previous mining experience, it became our plan to emphasize TRAINING from the start. That TRAINING would certainly include the safest procedures in performing every task. Until July of 1973 the TRAINING was conducted by myself and Mr. Gene Webb, our first General Superintendent of Undergound Mines. Martin County Coal was probably one of the first companies to require its employees to attend TRAINING & RETRAINING sessions on an annual basis. This originated in 1971, long before Federal law mandated safety training and retraining. The company did this on Saturdays or after the regular shift and paid overtime rates to the workers.

On July 9, 1973, Mr. Ed Chafin was hired by Martin County Coal as its first Director of Training. He also served as the company mine inspector and safety official. Ed was returning to Martin County from West Virginia and as a renewal of a previous association with Martin County Coal Corporation. Mr. Chafin heads up a staff of four individuals who form an outstanding team of Training and Mine Safety personnel. In my estimation Ed Chafin is the premier Safety Training person in Kentucky. I'm calling on Ed at this time to cover the next part of this presentation.

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I appreciate the opportunity to discuss a few of my thoughts on TRAINING here today. Since our annual refresher training makes up the nucleus of our overall training efforts, most of my remarks on the "T" in ACTION will be directed toward this portion of our program. In complying with the mandatory Federal and State training regulations, our underground miners receive 16 hours and our surface miners and preparation plant employees receive 8 hours of training annually. All of this training is conducted in a meeting-room arrangement at our Training Center, and each session is scheduled to accommodate the wishes of the group being trained. In addition to the training required by the regulations, our supervisors conduct weekly safety meetings with their crew members at the beginning of the first shift of each week.

Unlike our meeting here today, our refresher sessions are trainee-participatory in nature. We encourage our employees to take an active and vocal role in each session and the training is planned and conducted to accomplish this goal. Lecturing is kept to a minimum. We strive to make each session totally different from the previous one. We utilize a 'team-teaching' concept and attempt to insure that a new instructor or facilitator begins a new segment of the training at least every 30 minutes. Our 4-member department is expanded during our refresher training to include a wide variety of guest speakers. For example, during the past couple of years we have been fortunate enough to attract guest trainers from MSHA, the Kentucky Department of Mines & Minerals, the Bureau of Mines, the University of Kentucky IMMR/BRASH group, West Virginia University, and a number of other temporary instructors from equipment manufacturers and neighboring coal companies. During the course of a 16-hour refresher program, our underground miners may be exposed to more

than 10 different instructors. We use anyone available who possessses a high degree of expertise in a particular health or safety subject. We also rotate the sometimes repetitious topics required by the regulations in order to assure that new material with a new slant is provided each year.

We use films, videotapes, slide programs, and other audio/visual aids to supplement and alter the pace of our training sessions. Once we have used an audio/visual program with a group, we never repeat it. An almost unlimited variety of excellent training aids is available to mine trainers and there are few programs that warrant being rerun.

We have found that our training sessions provide a superb opportunity for conducting useful health and safety research. Several valuable research projects have been incorporated into our annual refresher training and our employees take great pride in their contributions to these efforts. Notable examples of this were the research and development of an effective hands-on training program for donning the self-contained self-rescuer, and development and testing of several latent-image exercises to enhance trainee involvement in annual refresher sessions. These two examples were cooperative efforts with the University of Kentucky and the U.S. Bureau of Mines.

Our company has developed numerous competitive instructional games dealing with a wide range of mine health and safety subjects. We use this format extensively in our training programs and have found that learning and retention are improved. In addition, our employees really enjoy the competition.

It is not a coincidence that the nicest structure on our mining property is our Training Center. Our company invested in the future of our operations in 1982 by building a training facility that is second to none in the coal industry. It includes 2 large classrooms with theatre-type seating, the latest in audio/visual equipment, and about everything else necessary to conduct effective training sessions. The facility also contains offices for our training staff, a conference room, a mine rescue and first aid station, and space for our company ambulance service. This structure provides confirmation of Martin County Coal's confidence in the value of training.

We know that TRAINING is one of the essential elements in our total safety formula. We believe we are getting an excellent return on our training dollars by constantly changing and improving our programs. We do this by tailoring our training efforts to our employees' needs and our particular mining conditions and equipment.

In concluding my remarks on training I would be less than candid if I failed to express my personal opinion on why our efforts have been successful. The greatest safety and training minds in the world would be totally ineffective without a compelling force and appropriate direction from the individual at the top. Mr. Bradbury has certainly provided those indispensable cornerstones for Martin County Coal Corporation since its beginning. As a safety and training professional, I am convinced that I have the most desirable position currently available in the coal mining industry. I believe that because Raymond Bradbury is the president of our company.

Another important aspect of our safety program comes under the heading of INVESTIGATION. A few years ago our company decided that our accident reports were not inclusive enough. They did not really encourage our individual foremen to recognize their role in accident prevention. Our management felt that the individual foremen believed when an accident occurred all that he had to do was to report it. After that it was someone else's job to investigate it. The accident report form was redesigned to be an INVESTIGATION form. In addition to the individual foreman's original INVESTIGATION, our Training Office, along with the foremen and other employees, depending

upon the seriousness of the accident, conducts a follow-up INVESTIGATION. This INVESTIGATION is expected to be a thorough one and includes the injured employee and any witnesses. A final report is then issued by the Training Office. These reports are circulated to all mine supervisory personnel for their use in conducting safety meetings with their crews. One of the main objectives in this procedure is to focus attention on the fact that accident prevention is a basic responsibility of each foreman. This INVESTIGATION is also expected to gain the attention of the individual employee and help him understand how the accident could have been prevented. All of this attention to accident INVESTIGATION, we believe, places the responsibility for accident prevention where it belongs--with the worker and his foreman.

Another feature of our formula for a successful safety program is INCENTIVES. There is some difficulty associated with determining just how much INCENTIVES influence an accident-prevention program. We like to think that they do play a positive role in our program. Each month, individual employees receive a decal if they have worked without NFDL occurrence. Other decals are provided at the end of each year commemorating the total number of accident-free years without a lost-time accident. Recognition plaques are awarded to employees with accident-free records at 5-year increments. A drawing for a valuable safety award is conducted quarterly and includes each employee who works in a crew that experiences no lost-time accidents during the 3-month period. An attendance qualification for the individual worker is also tied into this awards program. These INCENTIVES, we feel, do register some impact on our accident-prevention program.

The "O" of our ACTION word is OBSERVATION. This feature of our program hasn't received as much attention as we believe it should. Job OBSERVATION is the act of following an individual employee through one complete cycle of his job. This is done to OBSERVE how well he or she performs the tasks and if he or she is following safe work procedures. These OBSERVATIONS are not required on a daily basis, nor is mine management requiring that reports be made as a follow-up to each job OBSERVATION. They are intended to detect unsafe acts or procedures if the employee is found to be lacking in this area. The employee is then counseled privately about the OBSERVATION and any incorrect procedure or unsafe act observed. If the worker performs the task correctly and follows all safety procedures during the OBSERVATION, he or she is then also recognized for that accomplishment.

OBSERVATIONS of job procedures or activities are not limited to planned times. On the contrary, every supervisor on the Martin County Coal job is expected to be an OBSERVER for unsafe conditions or practices at all times. There is a lot of surface activity on our property that can be observed at any minute of the day or night. General housekeeping is something every employee has a responsibility to OBSERVE and correct if action needs to be taken. In any case, we try to be good OBSERVERS and urge others to do likewise in attempting to prevent accidents.

The last letter of the word ACTION, the letter 'N', is one I'm going to take literary license with. The word "N"THUSIASM best concludes what I believe is a necessary ingredient. Safety is a subject that we need to get "fired up" about. We need to display interest and "N"THUSIASM if we intend to reduce accidents. Martin County Coal has people in leadership positions that are interested in worker safety. They are concerned that accidents to employees probably will result in pain and suffering and, perhaps, hospitalization. They also know that accidents are often costly. They know that accidents mean workers are not on the job. And they are very much aware that accidents can be prevented. They display "N"THUSIASM about safety, knowing that such an attitude can be contagious and affect other employees in the same way.

There is another word that can be used with the letter "N" in ACTION. That is NUMBERS. It is my personal belief that those of us who desire a

successful safety program must be aware of the NUMBERS that are associated with safety records. Accidents become statistics, the NUMBERS by which we keep score of our performance. It is important to reduce accidents to the lowest NUMBER we possibly can. The most important number of all is a goal of ZERO accidents, ZERO Incidence Rates, and most of all, ZERO fatalities. Other important NUMBERS to be mindful of are the days of work an injured employee is off the job. Encouragement can sometimes help reduce the NUMBER of days a worker loses. Another important NUMBER these days is the cost of compensation for injured workers. It is an important unit of cost to our business. A good accident prevention program can reduce those NUMBERS.

We've covered a lot of ground in relating our formula for success. It does require ACTION from everyone involved. I am fortunate to have supervisors and a staff who are COMMITTED to operating the safest possible mines that we can have. We have a good program but we can always do better. There are other features of our program that we could discuss as they apply to mine safety, but time will not permit.

We began this presentation by asking questions. I'm not sure we have provided the answers. Nevertheless, you now have some insight into what Martin County Coal has done. In conclusion, I restate that our program of safety is one of ACTION; AWARENESS, COMMITMENT, TRAINING, INVESTIGATION, OBSERVATION & "N"THUSIASM.

TECHNICAL SESSION TWO: MINE MONITORING

Chairmen:

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MINE ATMOSPHERE MONITORING SYSTEMS

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ABSTRACT

Mine Atmosphere Monitoring Systems (MAMS) are intended to monitor continuously the mine air at fixed locations in order to detect the presence of contaminants (such as CO or smoke from a fire), the levels of methane and oxygen, and the velocity of airflow. Further, MAMS are intended to alert mine personnel of a potentially hazardous situation in a time frame sufficient to safely evacuate personnel and/or initiate and execute proper corrective procedures. MAMS are intended to augment, not to replace, conventional methods for underground hazard protection,thus increasing the level of safety in underground mines.

In order to perform their intended functions, MAMS must be highly reliable and designed properly. Reliability is a function of the electronic components that are used to fabricate the system and subsequent calibration and maintenance of these components. In general, reliability of MAMS is independent of the mines in which they are installed and used. Design, on the other hand, can be very dependent upon the mine in which the system is to be used. Proper design of MAMS include the selection of appropriate monitoring locations and placement of transducers which can depend upon the layout of an underground mine.

It is the intent of this paper to discuss both the reliability and design aspects of MAMS in order to provide better understanding of these systems, their capabilities, and their limitations. Particular emphasis will be placed upon the use of these systems for automatic fire detection.

INTRODUCTION

The life-blood of any underground mine is its ventilation system. As large volumes of fresh air are coursed throughout the underground workings, breathable, life-sustaining atmospheres are maintained, providing a healthy working environment. As the air sweeps across a working face, deadly methane is diluted to safe levels, along with the ever-present dust that can rob an underground worker from enjoying the benefits of a longer life. Within the past few years, a technology has evolved to continuously monitor this precious air in order to make certain that it

remains as contaminant free as possible --and, in the event that an incident occurs which results in contamination of the ventilating air, to alert mine personnel of the situation as quickly as possible so that emergency procedures can be initiated.

This report discusses the evolving technology of Mine Atmosphere Monitoring Systems, including the rationale behind its development and the safety benefits it can provide when installed and used properly. The report discusses, in a general sense, the components used to fabricate a system and offers some insight into how to design such systems in order to provide for optimum hazard recognition.

The "Why" of MAMS

Historically, underground mines have relied on various types of "monitors" to keep abreast of the quality of mine air. Some of these monitors have been of the human variety, where a person's keen sense of smell and sight are often used to great advantage to detect the odors given off from smoldering or burning coal, or to discern the barely visible wisps of smoke travelling down an entry. The flame safety lamp is another good example of a contaminant monitor. When exposed to an oxygen-depleted atmosphere, the flame begins to die out, or when exposed to excessive methane levels, the flame lengthens.

As time progressed, hand-held methane sensors began to replace the safety lamp as an indicator of excessive methane. Hand-held velocimeters were used to measure ventilation air velocity. Respirable dust samplers were attached to miners' belts to measure their exposure during a working shift. The list goes on. All of these devices have gradually gained acceptance for use underground and they represent significant improvements in our ability to monitor mine air in order to maintain its ability to support life.

But these advances, as great as they may be, have a common thread, namely, that they require the presence of someone to use them. But what happens when someone is not there at the moment a hazard occurs? As mining technology has advanced during the eighties and will continue to advance into the next decade, the physical size of our mines is increasing. Twenty or thirty years ago, when someone "walked the belt" to check for hazardous conditions, the inspection took only a half hour or so; today, especially in some of our larger mines, the same type of inspection takes considerably longer.

MAMS are intended to add to the safety of miners by continuously monitoring the mine air and providing information to miners as to its quality and its quantity so that rapid, reliable warning of a developing hazard can be given. Such a system, when designed, installed, and maintained properly "acts" like a continuous inspector, always vigilant to the occurrence of some unforeseen, developing hazard. By distributing transducers throughout a mine in some well-planned, logical fashion, early detection of excessive methane, CO or smoke from fires, oxygen-depleted areas, and/or abrupt changes in airflow can be detected automatically with subsequent, appropriate warnings given.

This is not to say that a person's nose could not have smelled the characteristic odor from a smoldering coal fire before a CO or smoke sensor issued an alarm, but rather, if no one's nose was there to smell the odor, what would have happened? Does one wait until the returns have been inspected to find that a roof fall has occurred and that methane is above an acceptable level? It is questions such as

these that have prompted the development of MAMS technology, that is, the necessity of knowing when a hazard occurs independent of required, periodic examinations so that proper emergency responses can be initiated at the earliest possible times. The potential of MAMS to augment the degree of safety in our underground mines is great. This technology needs to advance, and in the process of advancing to educate mine personnel not only about its potential but also about its limitations, so that, in time, such technology gains credibility and acceptance.

The "What" of MAMS

MAMS cannot replace all of a person's abilities to locate and define all hazards, nor is it the intent of MAMS to do so. With this in mind, it becomes immediately obvious that such systems can perform a limited number of functions and therefore have limited capabilities. However, the capabilities of such systems, even if limited, need to be exploited. To do this, cause and effect relationships between measurable quantities which MAMS can detect and the nature of the occurrence producing these measurable quantities need to be defined and understood.

In general, MAMS are currently limited to the detection and measurement of the following quantities:

1. Carbon monoxide (CO) or smoke
2. Methane
3. Oxygen
4. Air velocity

The detection of low levels of CO or smoke is intended to provide for early warning of a developing fire, either in its incipient, smoldering stages or its very early flaming stages. To most users, this is obvious. However, a crucial point about such sensors should be made - namely, that they measure CO or smoke levels independent of the source of the CO or smoke. What this means is that such sensors have no capability of determining whether the CO that they are measuring is coming from a fire or from some non-fire related activity, such as welding or from the use of diesel-powered equipment. Routine activities such as these can sometimes produce a sensor alarm but it should be clarified that when such alarms do occur, this is a clear signal that the sensor is really doing its job, rather than a signal that the sensor has failed.

Methane sensors are designed to detect the presence of excessive methane accumulations. Methane buildups can result from outbursts, mining into large pockets of methane in the coal seam, inadequate ventilation of the working face, or ventilation reductions due to falls of roof or rib.

Oxygen sensors are designed to detect the presence of an atmosphere which has insufficient oxygen to support life. Oxygen-depleted atmospheres most often occur in caved or gob areas, but can also occur in active workings which are weakly ventilated. In some applications methane and oxygen sensors are used together to detect potentially explosive atmospheres.

Air velocity sensors are used to monitor the air velocity in entries which may be crucial to a mine's operation, such as a belt or track entry, or within an entry where contaminant-free air is crucial to the safety of miners, such as an escapeway. Typically, when the air velocity is reduced to some minimal level within a given entry, an alarm is given. Most unexpected velocity reductions are due to falls of roof or rib which increase the resistance to flow. Other causes would be stoppage of a ventilation fan, but this condition is usually detectable at the fan itself.

With the exception of oxygen-depleted atmospheres, the three other hazards of fire, excessive methane, and airflow reductions are hazards that can develop almost instantaneously, or over a short period of time. To rely solely upon periodic inspections, spaced at finite intervals, often of a few hours duration or longer, when there exists technology for essentially continuous inspection would appear to be an error in judgment - especially when the potential consequences of injury and loss of life are evident.

However, as with any developing technology, there exist negative aspects as well as positive aspects. For the most part, the positive aspects of these systems are addressed above. On the negative side, the systems currently in use are not inexpensive, both from the standpoint of initial capital investment and the standpoint of system operation and maintenance. The costs of system components, installation of the system, and subsequent use and maintenance of the system may often be substantial enough that smaller mines cannot afford the technology, although there does exist a cost-effective alternative using pneumatic sampling systems. Even for mines that are able to commit themselves to the use of such systems, complaints of reliability are often voiced, although system reliability has greatly improved in the last few years. Often, complaints of systems that fail to work as expected are due to inadequate or improper placement of sensors. For instance, placing a CO or smoke sensor in a dead-ended crosscut and calling it proper placement is not much different than trying to measure air velocity by installing a velocimeter in the same location.

In other cases, system failure can sometimes be due to the lack of commitment by mine operators to follow guidelines for routine maintenance and calibration. Allowing an uncalibrated or nonfunctional sensor to remain in place and calling it a fire sensor is like blindfolding a miner, putting a clothespin on his/her nose and asking him/her to do a preshift examination.

Some complaints are more reasonable, such as the sensitivity some CO sensors exhibit to other gases such as hydrogen, a gas generated during recharging of some batteries, or the non-linear behavior of methane sensors to concentrations in excess of 5%.

Most, if not all, of these problems are currently being addressed and there exist promising solutions in many of these problem areas.

The "How" of MAMS

The previous sections have outlined the rationale for using these systems and presented a general discussion of what such systems can be expected to provide in terms of safety. All of these factors, combined with the needs of a particular mine, provide the basis for deciding whether or not to make a commitment to purchase, install, and use such a system. Once a decision is made to go forward, what are the mechanics of the system itself?

In very general terms, MAMS can be subdivided into three basic sections. The first section is comprised of the transducers (or sensors) that are distributed throughout the mine, or that section of a mine in which the system is to be used. The types of sensors to be used are dictated by the needs of a particular mine. If the system is to be used only for fire detection purposes, then the only sensors necessary would be CO or smoke sensors. If a mine has methane problems, then a combined system using both fire sensors and methane sensors is in order. If airflow is

critical in certain areas, then velocimeters are added to the system. Finally, if O_2 depletion is critical in some areas, then O_2 sensors could be added to the system. The final set of transducers could be any one or any combination of the above, depending upon a particular mine's needs, the rationale for the system, and the regulatory requirements for use of such systems. Depending upon the areas in which the sensors are to be used, some may have to be permissible.

The second section of MAMS is the outstation. In a typical system, all transducers are electrically wired to the outstation,where power for the transducers is provided and signals from each transducer accepted. Transducers are individually connected to the outstations with separate wiring,or, all the transducers are connected along one set of wires to the outstation (a multiplex system). Once the outstation receives a transducer signal, it is transmitted electrically to an above ground control station, which is the third section of the system. Communication between the control center and the outstation allows one to set alarms and other system functions, such as transducer failure alerts. At the control center,readings from all sensors can be printed out on a periodic basis. This capability is important if trending of the transducer data is necessary. Some systems come with graphics capabilities which can greatly simplify record-keeping and data analysis. Often, such records allow one to reconstruct the time history of some accident or other occurrence. Most systems, at the very minimum, print out all sensor alarms and malfunction conditions.

The type of system just described is the basic system available today for mine monitoring. The complexity of the system depends upon the number of transducers required, whether the transducers must be explosion-proof or intrinsically safe, the size of the mine and other factors. Most control centers can process inputs from a few to several outstations and most outstations are capable of providing power to and accepting signals from a hundred or so transducers.

At a cost of about $1,000 or more per transducer, it becomes clear that the cost of the system increases substantially both with the number of monitoring locations and the number of transducers installed at each location. Once installed, regular maintenance and calibration of the transducers is required, and the larger the number of transducers, the more time required to perform these functions. The purchase, installation, use, and maintenance of MAMS require a significant commitment by mine personnel in both time and monies.

For many mines, the resources do not exist to make this commitment. Fortunately, there does exist an alternative to the system described above which allows for continuous monitoring for CO, smoke, CH_4 and O_2 and at a reduced cost. The alternative is a pneumatic sampling system (1,2,3) which utilizes polyethylene tubing and teflon-lined diaphragm pumps to pull gas samples from remote monitoring locations to a central station where the samples of gas are analyzed for the contaminants of interest. The simplicity of the system means that all transducers can be located in one convenient location, thus streamlining the procedures for maintenance and calibration. In addition only passive, non-electrical tubing extends from the central analysis station to the desired monitoring location, thus eliminating permissibility constraints. For a simple system which monitors only one contaminant, such as CO or smoke, the initial cost is considerably less than the initial cost for the conventional,

fixed-point transducer monitoring system because only one transducer is required to monitor several locations. However, the pneumatic system is not marketed commercially for use underground although all components necessary to implement such a system are readily available.

Fire Detection. Fires represent a major hazard in underground mines. They can be detected in their earliest stages of development by CO or smoke sensors. Of these two types of sensors, CO sensors have found the greatest usage in underground usage in underground mines. However, all of the data available indicate that smoke sensors are more sensitive than CO sensors and, in general, will provide for earlier warnings. Unfortunately, it is only recently that intensive underground testing of smoke sensors began in order to determine their reliability. The smoke sensor's greater sensitivity is due to two factors:

First, on a mass basis, they are inherently more sensitive. A smoke sensor will alarm at smoke levels of ~ 1 or 2 mg/m^3 of smoke, which corresponds to a smoke optical density of ~ 0.05 m^{-1}. On a mass basis, 1 ppm of CO equals 1.25 mg/m^3, so that at an alarm level of 10 ppm CO, the mass level is 12.5 mg/m^3. This is not to say that CO sensors cannot measure 1 or 2 ppm of CO. Indeed they can, but most mines have CO background levels of 2 to 5 ppm, so that to reduce false alarms, the CO alarm level must be set above this range.

Second the production of CO requires that a chemical reaction take place between the carbon in the fuel and the oxygen in the air. This implies that the rate at which CO is produced depends upon the amount of carbon in the fuel and, further, that sufficient heat be available to sustain the rate of formation of CO. Smoke, on the other hand, is produced by thermal processes during the incipient, smoldering stages of a fire and as soot particles in flames. Neither of these processes is chemically dependent. In due course, it should be expected that smoke sensors will be used extensively in underground mines. Regardless of whether a CO or smoke sensor is used, the manner in which they would be deployed is the same.

There is the question of spacing of fire sensors in entries, and, in particular, belt entries. The times at which CO or smoke arrives at a sensor location depends upon the ventilation air velocity. The lower the velocity, the more time it takes, and the higher the velocity, the less time it takes. At high ventilation rates, CO and smoke are also more severly diluted than at low ventilation rates. As a result, a larger fire is needed to produce sufficient CO or smoke to cause an alarm at a higher velocity than at a lower velocity. Dilution is a fact, and the fact is that, at higher air velocity, it will take a larger fire to produce the levels of CO or smoke produced by a smaller fire at a lower velocity.

However, all of the data available indicates that at higher airflows it also takes a larger fire to produce the same hazard at that which would result from a smaller fire at a lower velocity. A simple example will serve to illustrate this point.

Assume that in an entry that measures 6′ x 20′ the air velocity is 150 feet per minute. A fire produces CO at a rate which is proportional to the fire intensity and which is subsequently diluted by the airflow. Assume that the fire hazard is defined as that size of fire necessary to produce 200 ppm of CO. At the 150 ft/min velocity, 10 ppm of CO is produced when the fire intensity is about 1300 BTU/min, 200 ppm of CO is produced at a fire intensity of

about 27,000 BTU/min. Now, assume that the air velocity is 600 feet per minute. Ten ppm of CO is produced at a fire intensity of about 5,200 BTU/min., but it takes almost 108,000 BTU/min of fire intensity to produce 200 ppm. Consequently, even through it takes a larger fire to produce 10 ppm CO at the higher velocity, it also takes a much larger fire to produce the hazard level of 200 ppm of CO.

This example clearly indicates that in order to properly use fire sensors, the times to alarm must be tendered by some time to reach a defined hazard, such as the 200 ppm CO level given in the above example. The time between alarm and hazard represents the time that is available to react to the fire, either in terms of evacuation or control/extinguishment efforts.

If the rates of growth of typical fires are known, then the times to reach sensor alarm and the times to reach some defined hazard may be calculated and the reaction time determined. All of the data available indicates that, for air velocities of less than about 300 to 400 ft./min. the fire intensity increases at a rate which is proportional to the velocity of air. In the worst case, these rates have been found to vary with the square of the velocity. Above velocities of 300 to 400 ft./min. fire intensities will also increase but at a reduced rate which is not proportional to velocity.

For a fire in a belt entry, the relative time from the time at which 10 ppm of CO is produced until the time at which the fire is large enough to begin spreading along the belt is typically on the order of 10 to 20 minutes, independent of the air velocity. At low velocities it takes longer for the CO to reach a sensor than it does at higher velocities. This, in effect, means that most of the 10 to 20 minutes could be used just for the CO to reach a sensor. As a result, it would appear that at lower velocities, sensors need to be spaced closer together, so that more of the time can be used to react to the fire.

However, the spacings and times depend strongly upon how one defines the hazard. Belt flame spread is one hazard example. One could just as easily define the hazard as some high level of smoke or CO, or it could be the size of fire that results in fuel-rich burning, where the levels of CO can increase dramatically.

The study of fires, fire growth rates, and the hazards they present are subjects of on,going research. It suffices to say that detection should be as rapid as possible so that most of the time available can be used to respond to the fire.

Before concluding the discussion of fire detection, it should be mentioned that placement of sensors near the roof of an entry can often be crucial to the early detection of a fire. The CO and smoke from a fire rise due to buoyancy, especially near the fire, so that most of the CO and smoke exists in a stratified layer near the roof. As the CO and smoke flow down the entry, this layer dissipates due to mixing. Stratification is especially significant at the lower air flows (<200 or 300 ft./min.) Because of this effect, it is generally recommended that fire sensors be located near the roof at a distance from the roof no greater than about 25% of the total entry height.

CONCLUSIONS/SUMMARY

Mine Atmosphere Monitoring Systems (MAMS) offer significant potential for increasing safety in underground mines. Improvements in sensor sensitivity, sensor reliability and system reliability are continuously being made. For

many applications, pneumatic monitoring systems may be a cost-effective solution for monitoring of a mine's atmosphere. In the area of fire detection, smoke sensors offer the greatest potential for early warning. Spacing and location of sensors can be critical in many applications. Research into defining and modeling typical fire scenarios shows significant promise for developing strategies for optimizing spacing and for determining the significant hazards associated with fires.

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MINE MONITORING AT CONSOLIDATION COAL COMPANY

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INTRODUCTION

In many ways, Consolidation Coal Company's experience with Mine Monitoring has mirrored that of the industry. Once seen as an optional "extra" for an underground coal mine, Mine Monitoring Systems today are an integral part of productive operations. Some users estimated the payback of a Mine Monitoring System as from 1-5 years [1]. Consol often estimates the payback as immediate from a risk - management point of view.

What is a Mine Monitoring System? In this context, Mine Monitoring Systems will be considered computer-based systems that gather information from underground mine sensors and transport that information via a telemetry method to other mine locations. General Mine Monitoring functions can be subdivided into Atmospheric Monitoring and Production Monitoring [2]. Atmospheric monitoring samples the mine ventilation system for such parameters as oxygen, methane, hydrogen, carbon monoxide, smoke, and temperature. Production monitoring gathers information on the present status of mine production elements, such as running unit status, alarms, levels, tonnage, and availability. Atmospheric monitoring addresses risk management in terms of avoiding dangerous mine conditions. Production monitoring provides real-time and historical information as tools for mine management.

What is not mine monitoring? Mine monitoring is not computer-based real time machine control. In many ways, control capabilities on Mine Monitoring Systems have been oversold [3]. Control functions do not fit easily into a fill-in-the-blank programming environment. Safe and effective machine control requires an engineered solution for both hardware and software. Although Mine Monitoring Systems are capable of limited control actions such as remote stop/start, reset, and machine initialization, they are not well suited to high-level control actions. If the operator has a need for multiple logic schemes, timing, counting, mathematical or proportional control algorithms, a dedicated computer-based control system or a distributed computed-based microprocessor control is required.

OVERVIEW OF MINE MONITORING WITHIN CONSOL

Consol began using mine monitoring in the late 1970's with the design and

installation of two custom systems. A Bureau of Mines review in 1979 cites only a half dozen Mine Monitoring Systems in operation [4]. The Loveridge system was installed in 1977 and measured atmospheric parameters such as methane, air velocity, temperature, and carbon monoxide. It included a unique subsystem of surface seismic geophones that would locate and plot locations and magnitude of strata disturbances within the mine. By 1979, the Moundsville Operations of Consol undertook an aggressive program to install mine-wide production monitoring in three mines: Shoemaker, Ireland, and McElroy. This system reported status to a central operation attendant. The system measured production element status, fan status, car counts, tonnage, levels, availability, and some environmental parameters. In the 1980's, Consol began to purchase commercial Mine Monitoring Systems from vendors. The main system goal during this time was to monitor atmospheric parameters on belt lines, in order to obtain ventilation variances which would allow use belt air at the working face. By 1985, four of these systems were in place within Consol.

In 1986, Consol experienced a smoldering belt fire that was very difficult to contain at one of its mines. Management at that time investigated the status of early fire detection systems. The existing thermal-based belt line systems did not provide an alarm until the fire was well into a flaming or hot mode. It was generally agreed that in order to successfully deal with a belt line smoldering fire scenario, the operator needed a low-level early fire warning system [5] [6]. The best available technology for early fire detection was determined to be product-of-combustion sensors, such as low-level carbon monoxide sensors. By late 1986, Consol undertook a program to install carbon monoxide monitoring on all underground belt conveyors, independent of any ventilation or belt line fire alarm variance. Consol decided to operate such systems as a risk-management strategy in order to effectively protect our ability to produce coal for the marketplace. By 1987, all systems were funded and undergoing installation.

Today, Consol operates 19 mine monitoring systems purchased from five manufacturers. These have proven to be prudent tools for dealing with early combustion problems. Today, Consol is expanding systems in order to measure other environmental parameters on an "as required" basis. Some mines are expanding systems in order to monitor production elements on a productivity basis. We have gained practical experience on the operation of monitoring systems and have learned skills necessary to operate a Mine Monitoring System safely and reliably [7]. Based on that experience, Consol is cooperatively working with manufacturers to provide and install third-generation Mine Monitoring Systems with enhanced features.

MINE MONITORING SYSTEM SELECTION

Intent

It is intended that the mine operator select a Mine Monitoring System that will enhance the safety and productivity of the coal mine. The system will be assembled from various sub-components. The operator should examine each system component for compatibility with his mine conditions and system goals. Based on Consol's experience with Mine Monitoring Systems, I would like to outline some system selection criterion.

Computer

The engine of the Mine Monitoring System is the central computer. The Mine Monitoring System should be based on a computer platform that is commonly available and modularly configured for system functions. The computer

may be classified as a desktop unit for an office-type environment, or hardened for a NEMA-rated factory-floor-type environment. The computer shall be reliabile, and support fault tolerant or redundant configurations. The computer operating system shall support real-time multiple tasking or transparent interrupts with Atmospheric Monitoring System sensor scanning given the highest system priority. Today, central computer functions may be distributed to multiple computers or microprocessors. For example, an outstation could contain a local microprocessor capable of independent alarm and operator display. This intelligent outstation could communicate with other similar outstations and an area supervisory host computer. This area host may be located in the underground mine at a panel area as part of an MSHA-classified AMS system. This area computer may communicate with a Level II host computer located outside of the mine. In this manner, the sub-components of an integrated Mine Monitoring System become modular, and are added in a sequential manner as the mine expands. Secondly, the multiple computer nodes of the integrated Mine Monitoring System provide the system with a greater level of failure tolerance to a single computer problem. Distributed architecture enhances system reliability and integrity. Distributed architecture allows for system moves, advances, and retreats with the mining faces while still monitoring producing coal elements.

Software

First-generation Mine Monitoring Systems often based their software on a programming language such as Assember, Fortran, Pascal, or "C". This required a system coordinator fluent in the particular language.

The second-generation Mine Monitoring Systems offered configuration based programming. The system attendant would configure the system by providing "fill-in-the-blank" information to system prompts [8]. The Mine Monitoring System software today includes multiple configuration editors and provisions for operator custom programming. It is desired that the Mine Monitoring System monitoring software operate within one of several industry-standard, factory-floor software shells. This type of software should support communication drivers and translators between the Mine Monitoring System database and other mine computer system. These computers may include Programmable Logic Controllers, Process Control Computers, Desktop Personnel Computers, Supervisory Control and Data Acquisition Computers, mining machinery microprocessors, longwall headgate controls, and electro-hydraulic shield controllers. The Mine Monitoring System is uniquely positioned to serve as a common gateway between these other mine computer systems.

Mine Communication

The Mine Monitoring System moves information to and from the underground data collection points to the surface computer via a wired data line. This data is subjected to electromagnetic interference, data frame collisions, and wiring faults that can produce data errors. The wiring path is a major contributor to reliability problems with any Mine Monitoring System. Once the system operator and manufacturer agree that these errors can and do occur, methods can be devised to cope with communication errors. First, the Mine Monitoring System should annunciate and document communication errors. "How many errors?", "When did the errors occur?", and "Are the errors common to a particular data line or outstation?" are questions that need to be answered by the Mine Monitoring System. Second, the Mine Monitoring System vendors are encouraged to add error detection and correction routines to their data transmission

protocols. Third, the data frame driver software and hardware should be equipped with memory buffers that will allow for the re-transmission of data packets until a successful transfer occurs. In most cases, it is more important that the data, or a sub-set of the data, get through to the computer than it is to maximize the speed of the scan of the atmospheric monitoring sensors. Finally, the Mine Monitoring System should be provided with the capability to install data loops underground between outstations. The system with loops should then be able to recognize and isolate bad wiring paths in order to maintain data transportation.

Input/Output Structure

The input/output structure is the interface between the mine sensors and the Mine Monitoring System data communication protocol. The input/output structure connects to sensors and devices using industry standard voltage and current ranges for analog and digital signals. The operator is encouraged to define his needs for the I/O structure. The number of I/O points, the electrical ranges of the channels, the fail-safe mode of the channel, the flexibility for change are important considerations. For safety, the outstation input/output channels should be electrically isolated from adjacent channels. To reduce the number of field wiring pairs within the mine, the Input/Output structure should support two-wire multiplexing of multiple sensors. The Mine Monitoring System Input/Output should be modular, and capable of expansion in the mine by mine personnel. The battery back-up capacity to support the desired sensors should be confirmed prior to deployment. The input/output structure should provide for systems access to permissible areas of the coal mine [9]. Vendors are encouraged to provide fiber optic interfaces and sensors for input/output. Fiber optics provide an enhanced level of noise immunity in areas of high mine electromagnetic interference, and a safe means for a low level energy exchange of signals that enter permissible areas of the mine.

Sensors

Mine sensors provide the sight, hearing, touch, and smell attributes to the Mine Monitoring System. The sensory device choices and locations within the mine are major operator design parameters. A dominant cost in the operation of any Mine Monitoring System is the installation and maintenance of the existing atmospheric sensors [10]. The operator should examine the calibration requirements, sensor life, and enclosure ratings for each sensor. The operator should be aware that some sensors exhibit a cross sensitivity to interferents. Carbon Monoxide sensors are the most common early product-of-combustion sensors in use today. Manufacturers are developing new AMS sensors.

Man/Machine Interface

The modern manager operates his mine from underground. On any working shift, the decision makers in the mine are located at many distributed locations. The Mine Monitoring System function is to provide information to management. The Mine Monitoring System tends to centralize this information. It follows then, that the Mine Monitoring System should provide a distributed man/machine interface to supply the monitoring information to the managers. The coal mine operator is most qualified to decide the location, type, and complexity of the information display [11]. The most common Mine Monitoring System man/machine interface presently is a CRT display and printer located on the surface of the mine. With the availability of small, inexpensive, factory-floor interface devices such as light mimic panels, text message displays, flat-screen LCD displays,

compact low level CRT's and intelligent color graphic display terminals, the Mine Monitoring System should allow the operator to provide information, messages, alarms, trends, and prompts to the management staff at any mine location. To make this practical, the Mine Monitoring System man/machine interface device should be provided with a system access port on any outstation.

MINE MONITORING SYSTEM INSTALLATION AND OPERATION

The operator should develop a plan for Mine Monitoring System installation and operation. The plan should address the operator's goals for atmospheric and production monitoring. For atmospheric monitoring, the operator should define the environmental parameters of interest, the locations of the sensors within the mine ventilation network, and the range and sensitivity of the sensors. The operator should define warning and alarm levels for each environmental sensor. The operator should define the sensor periodic calibration requirements. A written plan should address the attendant responsibilities upon a system alarm or malfunction. All system attendants should be trained in system acknowledgment and in alarm-response procedures. Investment of time in response training is a basic requirement of system installation.

For production monitoring, the operator must detail the mine status points of interest for management information collection. Each status point will require a wired interface between the production element and the monitoring input/output structure. Where practicable, this interface should take into account the possible exchange of energy between the two systems from a fail-safe or working lockout safety point of view. The monitoring system should not add any hazards to the equipment. The operator must define the range, resolution, and fail-safe nature of each measured analog sensor. The operator should examine the nature of connected mine production elements, which cause many alarms to occur in an interlocked fashion. For example, a belt conveyor slip switch alarm usually causes a belt shutdown. The monitoring system must be properly interfaced in order to time stamp the proper order of occurrence of events. The operator must examine the power-off status of monitored elements. A local power outage at a particular mine location often can cause false reports of events.

In order to facilitate Mine Monitoring System installation and operation, Consol usually designates a system coordinator at each mine. The coordinator is selected from the normal mine staff and provided with system training. It is more important that the coordinator be familiar with he mine layout, ventilation, production elements, and mine information needs of management, than to be versant in Mine Monitoring System terminology. The system coordinator needs to function as a system proponent, disciple, advocate, and mentor. The coordinator role is not a permanent, or full-time position. When the coordinator is moved or promoted into other mine staff positions, he trains the next coordinator. Former coordinator exposure to system capability has proven beneficial to expanding the Mine Monitoring System installation base. To back up the system coordinator at each mine, Consol provides support personnel with technical system training at the Operations, Regional, and Corporate levels.

SUCCESSES AND SHORTCOMINGS OF MINE MONITORING SYSTEMS

Consol has found Atmospheric Monitoring for product-of-combustion gases to be a prudent risk management tool. On several occasions, early

detection of smoldering fire scenarios have allowed our operation staff to successfully negate these occurrences as a hazard to personnel and mine production capability. Today, it is not in our best business interests to have only a plan for fire recovery at an affected producing mine element, but to spend capital now on systems that may prevent a major fire. Consol's business plan is to have zero tolerance for unexpected mine fires. It is our responsibility as professional coal mine operators to assure that proper and prudent operation of the mine ventilation system is occurring on every working shift. Atmospheric Monitoring tasks are the cornerstone of any Mine Monitoring System installation.

Production monitoring has provided real-time status information to operations. This has allowed managers to make intelligent decisions on the allocations of resources to problems. Production rate information has allowed management to assess and document production limits and capabilities. This information has been valuable in allocating budget resources for mine production equipment enhancement and upgrade. The scope of production monitoring within the coal mine will continue to expand.

The installation and operation of Mine Monitoring Systems have also made evident some system shortcomings and problems. The existing Mine Monitoring System central computer equipment and software needs reliability improvements [12]. The operating reliability of Mine Monitoring Systems within Consol has not been as good as that of Programmable Logic Controller and Process Controller equipment. Mine Monitoring Systems need improved methods of expansion and modernization. Systems need to be smaller, more modular, and less costly so that they may be replaced more frequently in order to take advantage of technical improvements. The life-cycle cost of atmospheric sensors needs to be reduced. The sensor installation, start-up, and calibration require too many service man-hours of valuable service staff time. The location and placement of AMS sensors is sensitive to their success. Interferent gasses, vibration, excessive dust, and moisture present operating problems. Mine Monitoring System documentation, drawings, and troubleshooting information has been difficult to obtain and maintain. Most system information is conveyed from the manufacturer to the user verbally. Communication between existing Mine Monitoring Systems and other mine computer devices has been cumbersome. Mine Monitoring Systems need improved methods of recording past alarms, occurrences, and trends. These records need to be secure. Most Mine Monitoring Systems would benefit from enhanced multiple-level password, security-based access to important records, configurations, and system set-up.

CONCLUSION

The evolution of Mine Monitoring System features is based on manufacturing volume and operator need. In 1981, a Bureau of Mines analysis projected a future market of between 34 to 83 million dollars in Mine Monitoring System sales within the next 10 years [13]. Basically, this has not occurred. Manufacturers estimate the present market is 3-to-5 million dollars annually, and depends on future regulatory policy. The Mine Monitoring System market is not so large or healthy as to support aggressive research and development. Manufacturers and users must then fully utilize the monitoring and computer products that have been developed for other factory floor industries. Manufacturers can then devote their resources to developments that are required for the specialized needs of coal mining. Operators must be aggressive in borrowing and

implementing applications from other industries. Consol's relationship with both Conoco and Du Pont has provided global information on the application of computers to industrial processes.

Mine Monitoring Systems will benefit from industry standards. Presently, other than an MSHA evaluation for mine-wide monitoring and the particular requirements of variances, there are few standards in place for Mine Monitoring System equipment. A supplier with a garage, a computer, and an advertising budget can be in the Mine Monitoring System business. There is an ongoing working project under the auspices of the Institute of Electrical and Electronic Engineers, Industry Application Society, Mining Industry Committee to develop and publish a recommended practice standard for "Atmospheric Monitoring Systems for Underground Coal Mining" as PAR #1203. The working group has drawn participation from industry, government, academia, and manufacturers. The first draft of this recommended practice should be issued by the end of 1989. As a participant in this process, I would welcome the involvement of any interested party.

It is generally acknowledged that most present Mine Monitoring Systems have been installed in the U.S. as Atmospheric Monitoring Systems, in order to receive an MSHA variance under the ventilation rules [14]. This driving force has sometimes biased the industry to consider only the requirements and needs of the variance plans. In 1985, an MSHA pre-proposal required additional environmental monitoring in gassy mines. Regulatory proposals have precipitated a boom-and-bust cycle in the development of new features. I would submit that in order to design and install an effective Mine Monitoring System today, the operator needs to consider the risk management, production monitoring, recordkeeping, and supervisory information needs of the coal mine in addition to the needs of the Atmospheric Monitoring System. The operator should attempt to divorce the Mine Monitoring System design from the variance request process. In this manner, the Mine Monitoring System can provide a valuable contribution to the operation of a productive and safe coal mine.

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STATE-OF-THE-ART MONITORING AND COMPUTER ANALYSIS OF THE RESULTS FOLLOWING A RECENT MAJOR MINE FIRE

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ABSTRACT

In March, 1988, a fire occurred in a large underground coal mine. Coal Mine Safety and Health of the Mine Safety and Health Administration was immediately notified of the situation. They requested the assistance of the Pittsburgh Health Technology Center (PHTC) to provide monitoring and analysis of the mine atmosphere in and around the fire area to insure the safety of the miners escaping from the mine and of the miners involved in extinguishing the fire. The capability to provide this type of assistance is maintained by the PHTC Offices located at 4800 Forbes Avenue, Pittsburgh, Pennsylvania. The equipment used is maintained in a field-ready state and can be mobilized almost immediately. This paper will discuss the response to this recent major mine fire.

INTRODUCTION

At approximately 10:30 p.m. on Monday, March 7, 1988, a fire was discovered in a belt entry near a belt drive in a large underground coal mine. The mine employed approximately 333 miners. Ventilation for the mine was induced by three exhaust fans, referred to in this paper as the A, B and C Fans. Air entered the mine through four intake openings, referred to as the No. 1, No. 2, No. 3 and No. 4 Intakes. The events following the initial detection of the fire will be separated into six phases. These phases are:

Phase I - Underground Fire Fighting,
Phase II - Evacuation,
Phase III - Remote Sealing,
Phase IV - Reventilation,
Phase V - Re-entry, and
Phase VI - Shafts Sealed.

This paper will discuss the preceeding events related to gas monitoring and evaluation accomplished by the Pittsburgh Health Technology Center (PHTC) of the Mine Safety and Health Administration (MSHA).

PHASE I - UNDERGROUND FIRE FIGHTING

The fire reportedly started in the belt entry near a belt drive that was located approximately 100 feet inby the intersection of two sets of main entries for the mine. At that time, there were approximately 29 miners working in three active working sections inby. These miners were notified of the fire and told to evacuate the mine. Using their self-contained self rescuers, all of these miners were able to escape safely from

the mine.

The fire was initially fought with fire extinguishers and water hoses. However, the fire continued to spread. The airflow over the fire was decreased by opening a door to permit the air from the belt entry to flow into an adjacent return entry and by installing a check curtain across the belt entry inby the open door.

The Mine Safety and Health Administration, Coal Mine Safety and Health, was notified of the fire shortly after midnight on March 8, 1988 and immediately responded with inspection and Mine Emergency Unit (MEU) personnel. At approximately 12:45 a.m., the PHTC was requested to report to the mine with its Mobile Sampling Vehicle (MSV) and Mobile Laboratory. Upon the arrival of PHTC personnel at the mine, it was decided that the MSV should be set up near the Ca Fan in order to continuously monitor the air existing the mine (the air passing over the fire exited the mine through the C fan. The MSV is equipped with infrared and electrochemical detection equipment in order to continuously analyze for carbon monoxide, carbon dioxide, oxygen and methane. It can draw an air sample through 3/8-inch diameter plastic tubing using an exhaust pump from over one mile away. Figure 1 depicts the gas-monitoring equipment set up at the C Fan. The first sampling location at the Ca Fan was completed at approximately 6:00 a.m. The concentration of methane and carbon monoxide was 0.4 percent and 0.1800 percent, respectively.

The Mobile Laboratory was stationed near the portal where miners entered the mine in order to analyze vacuum-bottle air samples that were taken underground or at any surface-sampling location. This vehicle is equipped with three gas chromatographs and is capable of analyzing air samples for carbon dioxide, carbon monoxide, methane, oxygen, ethane, ethylene, acetylene, hydrogen and nitrogen.

Fire-fighting operations were continuing underground with the arrival of

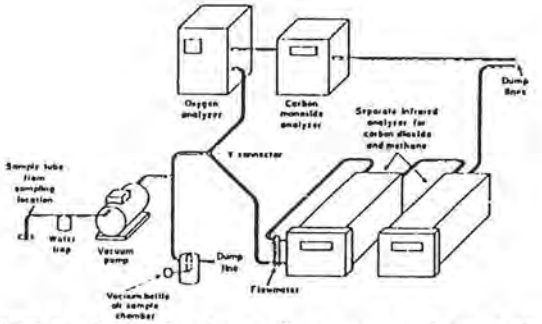

FIGURE 1 - Gas monitoring equipment setup of the shaft

mine rescue teams, foam generators, and other fire-fighting equipment. A new water line was installed to transport additional supplies of water to the fire. Although progress was being made in fighting the fire, it apparently continued to spread inby.

At approximately 7:00 a.m., MEU personnel set up an underground monitoring station using electrochemical detection equipment to monitor for methane, carbon monoxide and oxygen. The station was set up outby the fire area and a sample line of 3/8-inch diameter plastic tubing was installed in order to monitor the atmosphere in the left and right return entries. Most of the air passing over the fire exited the mine through these return entries. The initial concentrations in the right return entry were methane, 2.5 percent, carbon monoxide, 0.0600 percent, and oxygen, 18.0 percent. The initial concentrations in the left return entry were methane, 1.3 percent, and oxygen, 19.3 percent.

A sampling line was installed approximately 4,000 feet from the right return entry through the main entries and up the No. 4 Intake Shaft to the MSV so that, in the event that the underground sampling station had to be abandoned, monitoring of the atmosphere in that right return entry would still be possible. This installation was completed at 6:00 p.m. on March 8, 1988. The initial concentrations in the right return entry were methane, 0.3 percent, and carbon monoxide, 0.1310 percent.

Fire-fighting operations were continuing underground. A new water line was in operation as well as a larger-capacity foam generator and numerous fire hoses. However, by 8:00 p.m., the outby extent of the fire was reported to be inby 10 crosscuts, and over four entries to the right and one entry to the left of the suspected point of origin. The inby extent of the fire was unknown. At 8:30 p.m., rescue teams entered the left return to investigate a possible problem with the sample line installed for the MEU's underground sampling station. In the process of moving the line to an adjacent entry, the rescue team reported a dangerous concentration of combustible gas and exited the return. Almost simultaneously, the MEU reported a concentration of greater than four percent combustible gas at their monitoring station and the immediate evacuation of the mine began. By 10:30 p.m. all personnel were out of the mine and the power underground was turned off. The methane and carbon monoxide concentrations at the C Fan were 0.39 percent and 0.3100 percent, respectively.

PHASE II - EVACUATION

Monitoring of the atmosphere from the C Fan and from the right return entry via the sample line installed previously continued. On March 9, 1988, at 1:55 a.m. the explosion doors were opened on the C Fan in an effort to reduce the amount of air going into the fire area. The methane and carbon monoxide levels at the fan dropped from approximately 0.6 percent and 0.2100 percent at 12:40 a.m. to 0.4 percent and 0.1650 percent at 8:00 a.m., respectively. However, the methane and carbon monoxide levels in the right return entry increased from 0.2 percent and 0.1490 percent at 3:30 a.m. to 1.0 percent and 0.4300 percent at 8:00 a.m.

In an attempt to further reduce the amount of air going into the fire area, the C Fan was turned off from 5:10 p.m. to 7:05 p.m. and a blade change was made. However, by 11:00 p.m. the methane and carbon monoxide levels had increased to 1.0 percent and 0.2290 percent at the fan and to 1.0 percent and 1.4800 percent in the right return entry underground.

The concentrations at both locations began to decrease until around 6:00 a.m. on March 10, 1988. At that time, an event occurred underground. The fan pressure recording gage at the C Fan jumped from 3.8 inches to 0.0 inches of water and then back to 4.1 inches of water. The smoke coming from the C Fan turned from a grey to a dark black. Carbon Monoxide readings went from 0.1600 percent prior to 6:00 a.m. to over 0.6800 percent by 8:00 a.m. The sampling line going underground became plugged shortly after 6:00 a.m. At 9:46 a.m. the C Fan was turned off. At 9:52 a.m. the A Fan was turned off, leaving the B Fan as the only fan ventilating the mine.

PHASE III - REMOTE SEALING

With two of the three ventilating fans for the mine turned off, there was concern that methane could accumulate underground and that an explosion could occur. All personnel were removed from within 1,000 feet of any mine opening. This included the personnel in the MSV at the No. 4 Intake and C Fan and in the Mobile Laboratory near the portal. The MSV was relocated approximately 1,000 feet away and the sampling line to the No. 4 Intake and C Fan was extended so that continuous monitoring could be maintained. The Mobile Laboratory was relocated to a field near a power borehole, which was located approximately 0.5 miles from the portal.

As it was not possible to have personnel seal off the fire area underground, a plan to remotely install underground seals from the surface was initiated. This plan required the drilling of approximately 23 boreholes into the mine in which a limestone - grout mixture would be pneumatically blown into the con-

necting entries to seal off the fire area from the rest of the mine. The timeframe from start to finish was projected to be 30 days. Some of the complications were the hilly terrain, the lack of roads to the locations where the boreholes were to be drilled, the inexperience in a method of remote sealing that had not been proven on such a large scale, and the fact that the extent of the fire was not definitely known.

In order to minimize the risk to the personnel working on the remote sealing operation, a continuous sampling and monitoring program was initiated involving the cooperative efforts of several agencies. It consisted of the MSHA's MSV, which was located at the No. 4 Intake and C Fan (although the fan was off, the air continued to exhaust the mine through the return shaft). The Pennsylvania Department of Environmental Resources, Office of Deep Mine Safety Mine Emergency Vehicle was equipped with continuous monitoring capabilities similar to the MSV and was located at a ventilation borehole, referred to as Ventilation Borehole No. 1 (VBI), that was located in a gob area adjacent to the fire area. The State of Ohio's Mine Emergency Vehicle was equipped with a portable gas chromatograph and was located at a borehole, referred to as Sample Borehole No. 1 (SBI), that was drilled into the main entries inby the initial fire area. Vacuum-bottle air samples and hand-held instrument readings were taken at the A and B Fans. Other sampling locations were included as they became available. They will be referred to as the Sample Borehole No. 2, (SB2), the Ventilation Borehole No. 2 (VB2), the Sample Borehole No. 3 (SB3) and the Sample Borehole No. 4 (SB4). The SB4 Borehole was drilled into one of the working sections inby the fire area. The Pennsylvania Office of Deep Mine Safety Emergency Truck was relocated in order to continuously monitor the SB4 Borehole after its completion.

As a supplement to the continuous monitors, 50 cc vacuum bottles were taken at each of the indicated locations approximately three times daily. The samples were analyzed by the mobile laboratory for carbon dioxide, carbon monoxide, methane, oxygen, ethane, ethylene, acetylene, hydrogen and nitrogen. The results of all of these samples were logged into a computer where various calculations were done in order to determine the characteristics of the fire. Tables 1 and 2 show the results of these calculations at the C Fan during this phase of the operation. Some of the indices tracked carefully during this operation were the CO Index, the CO/CO2 Ratio, and the Explosibility Index.

The remote sealing operations were completed on March 30, 1988. The amounts of material pumped underground through the boreholes ranged from 15 to 411 tons per borehole. Prior to beginning the reventilation of the mine, a blade change was completed on the C Fan and a smaller motor was installed on the A Fan in order to reduce the quantity of airflow into the mine. The start-up of these two fans was scheduled for the morning of April 1, 1988.

PHASE IV - REVENTILATION

The reventilation procedure was to start up the A Fan, allow it to stabilize, and then to start up the C Fan. The fans were then to run a period of approximately 72 hours in order to permit the atmosphere in the mine to stabilize before consideration would be given to proceeding underground.

In addition to the continuous monitoring at the C Fan, SB4 and SB1 Boreholes, a continuous monitoring station was installed at the A Fan. Sampling locations included the SB2, VB1, VB2 and SB3 Boreholes and the B Fan.

The A Fan was started at 8:10 a.m. On April 1, 1988. The carbon monoxide reading shortly began to increase until they reached a maximum of 0.1808 percent at 8:40 a.m. and then began to slowly decline. The C Fan was started

TABLE 1 - C FAN CALCULATIONS - PHASE III

DAY	TIME	DATE	% CO2	% O2	% CH4	% CO	% H2	% C2H6	% N2	% C2H4	% C2H2	CO IND	TRIKET RATIO	CO2/ DEL O2	CO2 IN BLKDMP	WILLET RATIO	CO/CO2
12	200	03/19/88	2.16	17.79	.71	.3100	.4900	.0261	78.50	.0099	.0009	10.290	.754	71.70	15.595	14.883	.144
12	500	03/19/88	2.48	17.61	.73	.3100	.5000	.0192	78.34	.0098	.0005	9.841	.821	78.73	16.882	16.139	.125
12	930	03/19/88	2.62	17.16	.74	.3400	.5700	.0297	78.53	.0101	.0008	9.314	.749	71.77	15.642	15.017	.130
12	1430	03/19/88	2.34	17.49	.73	.3300	.5200	.0280	78.52	.0092	.0008	9.946	.741	70.53	15.391	14.728	.141
12	1935	03/19/88	2.37	17.71	.72	.3000	.5200	.0284	78.34	.0083	.0007	9.836	.808	77.70	16.699	15.941	.127
12	2200	03/19/88	2.37	17.89	.73	.2800	.5100	.0284	78.18	.0080	.0000	9.902	.867	83.81	17.777	16.907	.118
13	100	03/20/88	2.17	17.66	.70	.3100	.5000	.0271	78.62	.0074	.0005	9.766	.717	68.36	14.995	14.347	.143
13	500	03/20/88	2.32	17.36	.70	.3000	.4600	.0272	78.81	.0072	.0005	8.511	.689	65.82	14.559	13.986	.129
13	845	03/20/88	2.19	18.06	.63	.2900	.4800	.0248	78.68	.0062	.0005	10.394	.820	78.49	16.820	16.100	.132
13	1025	03/20/88	2.20	18.01	.61	.2900	.5000	.0246	78.35	.0060	.0005	10.535	.833	79.92	17.069	16.356	.132
13	1400	03/20/88	2.22	17.90	.63	.3300	.4700	.0245	78.42	.0060	.0003	11.453	.816	77.05	16.524	15.839	.149
13	1830	03/20/88	2.58	17.70	.67	.3300	.5200	.0260	78.16	.0066	.0005	10.955	.895	85.65	18.055	17.300	.128
13	2200	03/20/88	2.65	17.84	.59	.2900	.2200	.0512	78.34	.0085	.0000	9.931	.963	90.75	18.968	18.226	.109
14	200	03/21/88	2.18	17.98	.57	.2600	.5000	.0221	78.48	.0054	.0004	9.229	.799	77.38	16.663	16.027	.119
14	200	03/21/88	2.18	17.98	.57	.2600	.5000	.0221	78.48	.0054	.0004	9.229	.799	77.38	16.663	16.027	.119
14	500	03/21/88	1.60	18.81	.41	.1900	.6200	.0151	78.35	.0039	.0003	9.730	.813	81.94	17.454	16.807	.119
14	800	03/21/88	2.24	18.02	.59	.2600	.4900	.0230	78.59	.0052	.0004	9.265	.824	79.82	17.097	16.421	.116
14	1330	03/21/88	2.81	17.85	.53	.2500	.4600	.0208	78.07	.0033	.0000	8.807	1.015	98.99	20.387	19.704	.089
14	1700	03/21/88	2.11	18.08	.52	.2500	.5300	.0222	78.48	.0055	.0000	9.201	.797	77.65	16.713	16.114	.118
14	2105	03/21/88	2.30	18.03	.54	.2600	.5600	.0219	78.29	.0053	.0003	9.570	.867	84.66	17.936	17.277	.113
15	25	03/22/88	2.31	17.91	.60	.2700	.2200	.0242	78.66	.0057	.0004	9.206	.837	78.71	16.902	16.247	.117
15	430	03/22/88	2.28	17.82	.56	.2800	.6900	.0489	78.31	.0052	.0003	9.549	.790	77.76	16.719	16.087	.123
15	800	03/22/88	1.92	18.67	.46	.1800	.4300	.0198	78.26	.0046	.0000	8.700	.941	92.80	19.363	18.599	.094
15	1330	03/22/88	2.43	17.63	.68	.2900	.4400	.0257	78.49	.0060	.0004	9.149	.801	76.66	16.537	15.854	.119
15	1710	03/22/88	2.30	17.96	.70	.2600	.5200	.0257	78.23	.0055	.0004	9.383	.853	83.00	17.655	16.812	.113
15	2115	03/22/88	2.33	17.86	.68	.2500	.4800	.0263	78.37	.0056	.0003	8.597	.824	80.12	17.176	16.410	.107
16	10	03/23/88	2.24	17.95	.63	.2600	.5800	.0242	78.30	.0066	.0003	9.287	.818	80.01	17.131	16.402	.116
16	420	03/23/88	2.22	17.99	.60	.2400	.3900	.0243	78.53	.0047	.0003	8.509	.816	78.71	16.927	16.245	.108
16	800	03/23/88	2.16	18.10	.60	.2400	.2300	.0222	78.63	.0044	NA	8.769	.834	78.92	16.955	16.255	.111
16	802	03/23/88	2.27	18.15	.63	.2500	.2300	.0235	78.44	.0047	.0003	9.482	.910	86.10	18.189	17.380	.110
16	1345	03/23/88	.04	20.95	.00	.0000	.0000	.0000	79.01	.0000	.0000	NM	NM	NM	NM	NM	.000
16	1720	03/23/88	.04	20.95	.00	.0000	.0000	.0000	79.01	.0000	.0000	NM	NM	NM	NM	NM	.000
16	2120	03/23/88	.11	20.95	.04	.0000	.0000	.0005	78.90	.0000	.0000	NM	NM	NM	NM	NM	.000
17	1	03/24/88	.92	19.64	.54	.0840	.0461	.0110	78.77	.0032	.0003	6.807	.787	74.55	16.238	14.972	.091
17	430	03/24/88	.81	18.16	1.35	.1700	.1800	.0277	78.36	.0120	.0006	6.525	.343	31.09	7.484	6.679	.210
17	810	03/24/88	.04	20.95	.00	.0000	.0018	.0000	79.01	.0000	.0000	NM	NM	NM	NM	NM	.000
17	1300	03/24/88	.01	20.95	.00	.0000	.0019	.0000	79.05	.0000	.0000	NM	NM	NM	NM	NM	.000
17	1735	03/24/88	.21	20.85	.00	.0000	.0018	.0000	78.94	.0000	.0000	NM	NM	NM	NM	NM	.000
17	2140	03/24/88	.04	20.90	.03	.0000	.0018	.0000	79.03	.0000	.0000	NM	NM	NM	NM	NM	.000

LEGEND: ND = NONE DETECTED; NM = NOT MEANINGFUL; NA = NO ANALYSIS; ID = INSUFFICIENT DATA; C2H2 = ACETYLENE; C2H4 = ETHYLENE; C2H6 = ETHANE

TABLE 2 - C FAN CALCULATIONS - PHASE III

DAY	TIME	DATE	SAMPLE CONCENTRATIONS % CO2	% O2	% CH4	% CO	% H2	% C2H6	% N2	% C2H4	% C2H2	INERT	COMBUS	R FAC	MAX O2	TOT CH	UPPER	LOWER
12	200	03/19/88	2.16	17.79	.71	.3100	.4900	.0261	78.50	.0099	.0009	14.14	1.51	.46	8.21	1.55	25.59	5.12
12	500	03/19/88	2.48	17.61	.73	.3100	.5000	.0192	78.34	.0098	.0005	15.14	1.53	.47	8.26	1.57	25.58	5.13
12	930	03/19/88	2.62	17.16	.74	.3400	.5700	.0297	78.53	.0101	.0008	17.25	1.66	.44	8.06	1.69	26.33	5.10
12	1430	03/19/88	2.34	17.49	.73	.3300	.5200	.0280	78.52	.0092	.0008	15.57	1.58	.45	8.16	1.62	25.85	5.13
12	1935	03/19/88	2.37	17.71	.72	.3000	.5200	.0284	78.34	.0083	.0007	14.60	1.55	.46	8.20	1.58	25.64	5.07
12	2200	03/19/88	2.37	17.89	.73	.2800	.5100	.0284	78.18	.0080	.0000	13.75	1.54	.47	8.28	1.56	25.20	5.05
13	100	03/20/88	2.17	17.66	.70	.3100	.5000	.0271	78.62	.0074	.0005	14.77	1.51	.45	8.17	1.55	25.78	5.12
13	500	03/20/88	2.32	17.36	.70	.3000	.4600	.0272	78.81	.0072	.0005	16.32	1.45	.47	8.28	1.49	25.23	5.14
13	845	03/20/88	2.19	18.06	.63	.2900	.4800	.0248	78.68	.0062	.0005	13.34	1.40	.44	8.08	1.43	26.27	5.11
13	1025	03/20/88	2.20	18.01	.61	.2900	.5000	.0246	78.35	.0060	.0005	13.21	1.40	.43	7.98	1.43	26.80	5.10
13	1400	03/20/88	2.22	17.90	.63	.3300	.4700	.0245	78.42	.0060	.0003	13.73	1.40	.43	8.02	1.46	26.62	5.21
13	1830	03/20/88	2.58	17.70	.67	.3300	.5200	.0260	78.16	.0066	.0005	14.77	1.51	.43	8.02	1.55	26.62	5.15
13	2200	03/20/88	2.65	17.84	.59	.2900	.2200	.0512	78.34	.0085	.0000	14.52	1.08	.51	8.56	1.16	22.94	5.36
14	200	03/21/88	2.18	17.98	.57	.2600	.5000	.0221	78.48	.0054	.0004	13.43	1.35	.42	7.94	1.36	27.09	5.04
14	200	03/21/88	2.18	17.98	.57	.2600	.5000	.0221	78.48	.0054	.0004	13.43	1.35	.42	7.94	1.36	27.09	5.04
14	500	03/21/88	1.60	18.81	.41	.1900	.6200	.0151	78.35	.0039	.0003	9.27	1.29	.33	7.32	1.24	31.38	4.79
14	800	03/21/88	2.24	18.02	.59	.2600	.4900	.0230	78.59	.0052	.0004	13.47	1.36	.43	8.02	1.37	26.63	5.05
14	1330	03/21/88	2.81	17.85	.53	.2500	.4600	.0208	78.07	.0033	.0000	14.46	1.25	.42	7.93	1.26	27.12	5.07
14	1700	03/21/88	2.11	18.08	.52	.2500	.5300	.0222	78.48	.0055	.0000	12.94	1.33	.39	7.74	1.33	28.22	4.99
14	2105	03/21/88	2.30	18.03	.54	.2600	.5600	.0219	78.29	.0053	.0003	13.23	1.39	.39	7.72	1.39	28.38	4.99
15	25	03/22/88	2.31	17.91	.60	.2700	.2200	.0242	78.66	.0057	.0004	14.07	1.03	.54	8.75	1.12	23.01	5.41
15	430	03/22/88	2.28	17.82	.56	.2800	.6900	.0489	78.31	.0052	.0003	14.01	1.63	.35	7.47	1.58	29.12	4.87
15	800	03/22/88	1.92	18.67	.46	.1800	.4300	.0198	78.26	.0046	.0000	10.19	1.11	.42	7.94	1.09	26.98	4.93
15	1330	03/22/88	2.43	17.63	.68	.2900	.4400	.0257	78.49	.0060	.0004	15.14	1.40	.47	8.30	1.44	25.14	5.15
15	1710	03/22/88	2.30	17.96	.70	.2600	.5200	.0257	78.23	.0055	.0004	13.43	1.51	.46	8.24	1.51	25.47	5.01
15	2115	03/22/88	2.33	17.86	.68	.2500	.4800	.0263	78.37	.0056	.0003	14.00	1.43	.47	8.30	1.44	25.13	5.03
16	10	03/23/88	2.24	17.95	.63	.2600	.5800	.0242	78.30	.0066	.0003	13.45	1.51	.42	7.94	1.50	27.10	4.96
16	420	03/23/88	2.22	17.99	.60	.2400	.3900	.0243	78.53	.0047	.0003	13.50	1.23	.48	8.34	1.26	24.92	5.11
16	800	03/23/88	2.16	18.10	.60	.2400	.2300	.0222	78.63	.0044	NA	13.09	1.03	.55	8.83	1.10	22.74	5.33
16	802	03/23/88	2.27	18.15	.63	.2500	.2300	.0235	78.44	.0047	.0003	12.88	1.07	.55	8.87	1.14	22.56	5.34
16	1345	03/23/88	.04	20.95	.00	.0000	.0000	.0000	79.01	.0000	.0000	-.54	.00	.00	5.00	.00	.00	5.00
16	1720	03/23/88	.04	20.95	.00	.0000	.0000	.0000	79.01	.0000	.0000	-.54	.00	.00	5.00	.00	.00	5.00
16	2120	03/23/88	.11	20.95	.04	.0000	.0000	.0005	78.90	.0000	.0000	-.55	.04	.99	11.91	.04	14.96	4.96
17	1	03/24/88	.92	19.64	.54	.0840	.0461	.0110	78.77	.0032	.0003	5.52	.66	.79	10.52	.68	17.68	5.22
17	430	03/24/88	.81	18.16	1.35	.1700	.1800	.0277	78.36	.0120	.0006	10.57	1.71	.78	10.43	1.74	17.89	5.08
17	810	03/24/88	.04	20.95	.00	.0000	.0018	.0000	79.01	.0000	.0000	-.54	.00	.00	5.00	.00	75.00	4.00
17	1300	03/24/88	.01	20.95	.00	.0000	.0019	.0000	79.05	.0000	.0000	-.54	.00	.00	5.00	.00	75.00	4.00
17	1735	03/24/88	.21	20.85	.00	.0000	.0018	.0000	78.94	.0000	.0000	.03	.00	.00	5.00	.00	75.00	4.00
17	2140	03/24/88	.04	20.90	.03	.0000	.0018	.0000	79.03	.0000	.0000	-.33	.03	.94	11.60	.03	15.71	4.93

LEGEND: ND = NONE DETECTED; NM = NOT MEANINGFUL; NA = NO ANALYSIS; ID = INSUFFICIENT DATA; C2H2 = ACETYLENE; C2H4 = ETHYLENE; C2H6 = ETHANE

at 9:07 a.m. on April 1, 1988. The carbon monoxide readings remained low for approximately 30 minutes and then began to increase until they reached a maximum of 0.2000 percent at 11:15 a.m. They then began to slowly decline.

The continuous monitoring and analysis of the mine atmosphere during the next 72 hours became critical. The contaminant levels and their associated indices at most sampling locations began to decrease after the fans were turned on. However, on April 2, 1988, the carbon monoxide level at the C Fan increased from 0.1000 percent at 4:15 p.m. to 0.5800 percent at 6:40 p.m. It was possible that the remote seals were ineffective or that the fire had extended outby the seal locations. The increase in the CO Index and the CO/CO2 ratio also indicated that the size or the intensity of the fire was increasing. On April 3, 1988, the carbon monoxide, CO index and the CO/CO2 ratio began to increase at the SB4 Borehole.

As indicators in the fire area were increasing, it was decided that the only method to determine what was occurring in the fire area would be to proceed underground with rescue teams to evaluate the situation and then to determine a course of action. On the afternoon of April 4, 1988, all sampling locations were stable and non-explosive. As barometric conditions were also stable, it was decided to proceed into the mine with mine rescue teams.

PHASE V - RE-ENTRY

At 4:41 p.m. on April 4, 1988, rescue teams proceeded underground and began an advance towards the fire area. During this period, monitoring continued at the A and C Fans and at the SB1 and SB4 Boreholes. Vacuum bottle samples were taken on a regular schedule at the remaining locations.

The concentrations at all of the sampling locations remained stable during the re-entry into the mine. Mine rescue teams entered the portal and proceeded underground. They encountered roof falls across the main entries approximately 1,000 feet outby the fire area. The underground operations were then stopped because of the roof conditions encountered and all personnel were removed from the mine.

PHASE VI - SHAFT SEALING

On April 5, 1988, at 9:05 p.m., sealing operations at the top of the shafts began. These operations were completed by 2:00 a.m. on April 6, 1988. Sampling tubes were installed down approximately 100 feet into each of the shafts. A schedule was put in place to begin sampling each shaft on a weekly basis. These samples were sent to the PHTC where they where analyzed and logged. Indicator gas concentrations initially increased at the sampling locations and then began a slow decrease. Table 3 shows the results of the sampling at the C Fan during this phase of the operation. Figures 2 and 3 show the graphs at the CO index and the CO/CO2 ratio for the C Fan during this phase also.

As of January 9, 1989, the mine remains sealed.

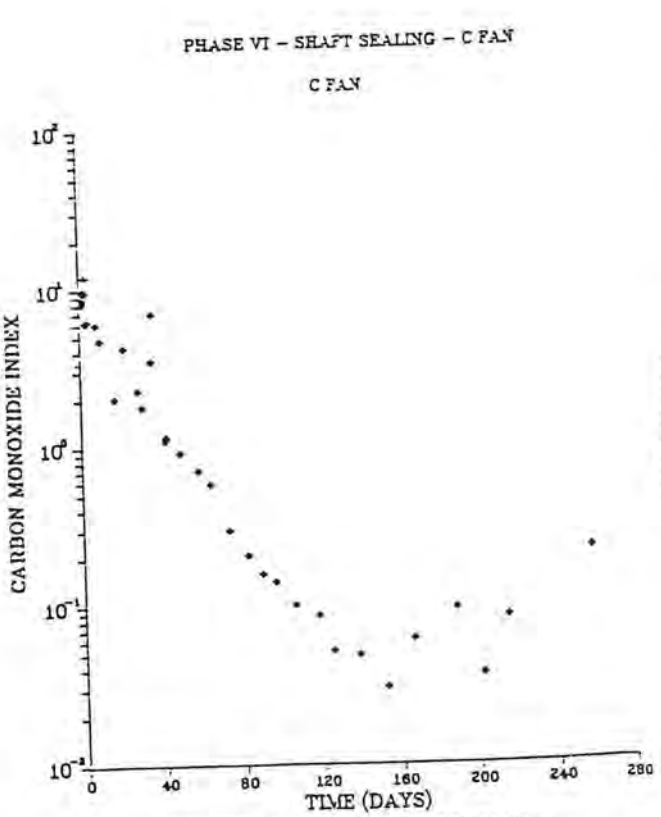

FIGURE 2 – Phase VI CO Index

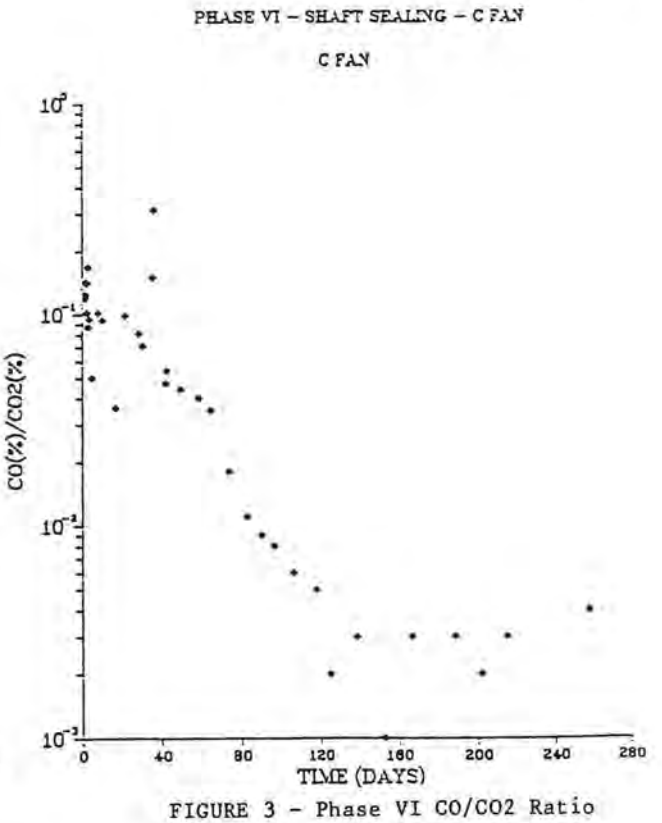

FIGURE 3 – Phase VI CO/CO2 Ratio

TABLE 3 – C FAN CALCULATIONS – PHASE VI

DAY	TIME	DATE	% CO2	% O2	% CH4	% CO	% H2	% C2H6	% N2	% C2H4	% C2H2	CO IND	TRIKET RATIO	CO2/ DEL O2	CO2 IN BLKDMP	WILLET RATIO	CO/CO2
1	407	04/05/88	2.59	17.15	.64	.3100	.3400	.0403	78.90	.0198	.0009	8.248	.728	68.91	15.148	14.629	.120
1	800	04/05/88	2.75	16.94	.64	.3400	.3800	.0408	78.90	.0193	.0011	8.567	.733	69.30	15.209	14.715	.124
1	1315	04/05/88	2.82	16.76	.61	.4000	.3900	.0434	78.93	.0208	.0007	9.624	.727	67.85	14.903	14.461	.142
1	1810	04/05/88	2.68	16.97	.58	.3800	.4000	.0410	78.94	.0160	.0010	9.622	.725	67.86	14.907	14.467	.142
1	2100	04/05/88	2.70	17.03	.57	.3800	.3900	.0398	78.89	.0154	.0006	9.804	.745	69.66	15.235	14.788	.141
2	500	04/06/88	.49	20.39	.11	.0500	.0600	.0064	78.90	.0023	.0000	9.643	.988	94.50	19.610	19.266	.102
2	1330	04/06/88	1.55	18.68	.52	.2600	.3600	.0243	78.60	.0088	.0000	12.099	.770	72.13	15.612	14.904	.168
2	1750	04/06/88	1.27	19.08	.48	.1100	.3100	.0202	78.72	.0067	.0000	6.177	.716	71.32	15.665	14.880	.087
3	715	04/07/88	2.53	17.07	.89	.2400	.3800	.0369	78.85	.0097	.0000	6.274	.684	66.14	14.692	13.998	.095
4	1115	04/08/88	.20	20.74	.04	.0100	.1500	.0020	78.86	.0006	.0000	NM	NM	NM	NM	NM	.050
7	1100	04/11/88	3.04	15.83	1.05	.3100	.4000	.0398	79.32	.0086	.0000	5.973	.611	58.58	13.243	12.683	.102
9	1140	04/13/88	2.24	16.68	.92	.2100	.3400	.0326	79.58	.0057	.0002	4.763	.525	50.81	11.725	11.210	.094
16	941	04/20/88	.42	20.20	.25	.0153	.0473	.0060	79.06	.0007	.0002	2.038	.559	55.93	12.836	12.153	.036
21	850	04/25/88	.58	19.66	.40	.0572	.0000	.0087	79.29	.0007	.0000	4.231	.461	42.90	10.097	9.539	.099
28	855	05/02/88	2.46	12.85	2.71	.2000	.0600	.0543	81.66	.0033	.0001	2.275	.295	27.99	6.859	6.381	.081
30	820	05/04/88	3.37	8.58	4.39	.2400	.0600	.0834	83.27	.0039	.0002	1.780	.262	24.99	6.177	5.717	.071
35	843	05/09/88	3.06	8.52	5.63	.4600	.0000	.0810	82.24	.0065	.0001	3.466	.257	23.05	5.702	5.161	.150
36	0	05/10/88	3.06	8.33	4.06	.9600	.0000	.0773	83.51	.0010	.0000	6.956	.274	22.17	5.449	5.083	.314
42	0	05/16/88	2.56	10.64	4.94	.1200	.0000	.0814	81.65	.0045	.0000	1.091	.241	23.28	5.789	5.207	.047
42	841	05/16/88	2.77	8.74	5.96	.1500	.0000	.0998	82.29	.0033	.0000	1.148	.221	21.20	5.298	4.755	.054
49	940	05/23/88	2.51	9.71	5.32	.1100	.0000	.0858	82.26	.0048	.0000	.910	.214	20.76	5.198	4.682	.044
58	1425	06/01/88	2.53	7.55	7.32	.1000	.0000	.1100	82.41	.0000	.0000	.700	.182	17.71	4.469	3.956	.040
64	1505	06/07/88	2.82	5.10	8.82	.0975	.0000	.1400	83.04	.0000	.0001	.577	.171	16.68	4.223	3.727	.035
73	1515	06/16/88	2.72	5.49	9.25	.0481	.0000	.1300	82.36	.0000	.0000	.294	.169	16.65	4.218	3.687	.018
82	1035	06/25/88	2.36	8.05	9.43	.0268	.0000	.1200	80.02	.0000	.0000	.204	.181	17.94	4.531	3.834	.011
89	1645	07/02/88	2.59	6.25	9.40	.0240	.0000	.1400	81.60	.0001	.0000	.156	.170	16.85	4.267	3.692	.009
96	225	07/09/88	2.43	7.16	10.03	.0196	.0000	.1400	80.22	.0000	.0000	.139	.173	17.24	4.362	3.693	.008
105	1735	07/18/88	2.28	6.94	9.95	.0143	.0000	.1400	80.67	.0000	.0000	.099	.159	15.79	4.012	3.411	.006
117	1400	07/30/88	2.91	5.54	11.95	.0131	NA	.1700	79.40	.0000	.0000	.085	ID	18.77	4.733	3.958	.005
124	2000	08/06/88	1.44	14.76	4.46	.0032	NA	.0800	79.24	.0000	.0000	.051	ID	23.08	5.758	4.886	.002
138	1350	08/20/88	3.01	4.68	14.18	.0076	NA	.2500	77.87	.0000	.0000	.048	ID	18.86	4.756	3.877	.003
152	1335	09/03/88	2.82	6.65	12.84	.0041	NA	.1800	77.50	.0000	.0000	.030	ID	20.31	5.101	4.133	.001
166	705	09/17/88	2.95	6.18	13.59	.0086	NA	.1900	77.08	.0000	.0000	.060	ID	20.71	5.196	4.186	.003
188	1030	10/09/88	.97	17.27	3.56	.0032	NA	.0700	78.14	.0000	.0000	.093	ID	28.22	6.950	5.538	.003
201	1510	10/22/88	1.08	14.73	6.37	.0021	NA	.0900	77.73	.0000	.0000	.036	ID	18.40	4.645	3.644	.002
214	1901	11/04/88	3.25	5.52	18.73	.0112	NA	.2500	72.24	.0000	.0000	.082	ID	23.86	5.939	4.414	.003
257	1520	12/17/88	.76	19.43	1.36	.0033	NA	.0400	79.10	.0000	.0000	.215	ID	49.62	11.605	9.649	.004

LEGEND: ND = NONE DETECTED; NM = NOT MEANINGFUL; NA = NO ANALYSIS; ID = INSUFFICIENT DATA; C2H2 = ACETYLENE; C2H4 = ETHYLENE; C2H6 = ETHANE

ATMOSPHERIC MONITORING SYSTEMS AND THEIR EXISTENT DEFICIENCIES

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During the late 1970's and early 1980's the Atmospheric Monitoring Systems (A.M.S.) were introduced to the mining industry. These systems were installed by operators as a trade-off for the requirement of 75:326 of Title 30. This occurs through the petition-for-modification process and was offered to pre-1969 mine operators through the ventilation plans. When the A.M.S. was introduced to the industry it was labeled as an early warning fire-detection device. This system was compared to the point-heat-type sensors which would require a flaming fire before a fire was detected and alarms activated. The purpose of the A.M.S. was to detect fires in their incipient stages and to alarm long before open flames occurred. The A.M.S. approvals eliminated for the most part compliance with 75:326; therefore, no longer would the operator be required to separate the belt and intake entries, to limit air velocities on belt conveyor entries and to direct belt air to the return.

In 1969, Congress--after evaluating the number of belt fires and studies by the B.O. mines which supported their actions--enacted the statutory provision of 303y, most commonly referred to by its regulatory reference, 75:326. According to B.O. mine reports for the period of 1960 to 1969, there were 525 fires that occurred in underground coal mines and for the 1970 to 1977 period there were 129 fires. In my opinion the '69 Act reduced those fires. Since the introduction of the A.M.S. and the increased air velocities, which I believe are relative, fires are on the rise again. During the period of 1978-1987, 280 mine fires were reported, which is better than a 100% increase. The number of reported fires on belt conveyors more than doubled since 1984, compared to years just prior to 1984. I realize that incidents of frictional heating may not have changed, but reported fires, fires that last more than 30 minutes, are increasing in numbers. These increased air velocities and lack of early warning of a fire are causing fires to burn for extended periods and at larger magnitudes. In many cases fires are more difficult to extinguish and, in fact, have caused mines or portions of mines to be sealed. MSHA approvals of the A.M.S. in the beginning included air velocities of a minimum of 50 fpm and a maximum to 300 fpm. MSHA's position in 1989 is that there is no unsafe maximum air velocity and that operators can have an infinite

amount of velocity if they wish.

Operators, MSHA and others with common interests claim that a 326 petition for modification and increased air velocity on belt entries is required because of methane problems. After 1969, nearly all coal mines which include pre-1969 mines complied with 75:326 and were safety operated. After 1980 and 10 years of compliance, these same mines supposedly can no longer comply and safely operate their mines. There are mines in the country that liberate high quantities of methane and may need some special attention. There are several options other than high air velocities in belt entries that can be utilized, such as moving belt conveyors away from longwall panels or implementing a degasification program at the mine.

For several years the UMWA has been trying to convince the industry, especially MSHA, that there are numerous A.M.S. problems which continue to exist; until recently MSHA would only look at the electrical aspects of the A.M.S. In May 1989, MSHA implemented an MSHA inspector-training program and an inspection procedure policy. This, in my opinion, is a major accomplishment. Finally, the agency that is charged with protecting the health and safety of the miners is concerned with the system's performance; therefore, we may be heading in the right direction.

Flame Spread Tests and Studies

The Bureau of Mines, along with MSHA's Approval and Certification Center, has performed numerous belt flammability tests and studies over the years. Until the 1980's these tests were performed only to assure, as required in 1969 by Schedule 2G, that fire-resistant belts were utilized in underground coal mines. Now, since the advent of the A.M.S., these tests are utilized to determine air velocities on belt entries. Belt entries in coal mines have numerous additional fire sources of which only the conveyor belt material is designed to be fire resistant. These tests did not simulate mining conditions with coal accumulations, coal seams, wood timbers or other normally found combustible materials. MSHA contends that the original maximum air velocities of 300 fpm on A.M.S. approvals was based upon the 2G test, which was performed with a 300 fpm air velocity. The 300 fpm velocity may have been derived from studies that compared the A.M.S. with point-heat-type sensors. The comparison occurred at air velocities between 50 fpm and 300 fpm. This study showed that, at the lower air velocities, the A.M.S. gave an earlier alarm than did the point-heat-type sensor, and at higher air velocities the A.M.S. was not as effective as the point-heat-type sensor.

In 1986, the Bureau of Mines performed belt flammability tests requested by MSHA in order to compare 300 fpm air velocities with an 800 fpm velocity. No direct focus was given to low air velocities when conducting these studies. Reports are available that show limited information on belt flame propagation at lower air velocities, and the results were favorable or equal to high air velocities depending on the belt being tested. Some of those published results are:

Belt type	Air. Vel.	Flame Prop. Rate M/Min.
sbr	150 fpm	0.24
sbr	300 fpm	0.92
sbr	500 fpm	0.34
sbr	800 fpm	0.37
pvc,ncb	150 fpm	0.00
pvc,ncb	300 fpm	0.00
pvc,ncb	500 fpm	0.00
pvc,ncb	800 fpm	0.00

When reviewing statistics of belt flammability tests at various

air velocities, there are three levels of flame propagation. Lower velocities of approximately 200 fpm and less smother a fire; levels of approximately 400 fpm to 800 fpm cool a fire at least for some period of time; and levels of approximately 300 fpm are in most cases the optimum conditions for rapid propagation of a belt conveyor fire. The air velocity of 200 fpm or less is the best of all three scenarios and in all stages of a fire. The 300 fpm is not good during any stage and the 400 fpm or greater is only good for a short period which occurs some time after the fire has started flaming and continues until the fire is large enough and has all the fuel that can be consumed.

As I stated previously, not all of the tests were performed in an environment that reflected the conditions in the mine. The Lake Lynn, B.O. Mine's test was performed in a tunnel lined with ceramic tile and having a concrete floor. The ignition source for the belt flammability test is a pan with 2 gallons of kerosene/gas mixture. This ignition source is not of the type with which most belt fires start. The UMWA has asked the Bureau of Mines and MSHA for several years to simulate a frictional heating fire origin with coal piled beneath and around the belt conveyor and to add other coal-mine-related combustible materials. In that type of test the flame would not only travel down a fire resistant belt which is constructed not to burn easily, but would burn off to the sides of the belt conveyor. This type of test would be more accurate and, in my opinion, results would be unfavorable for high velocities because the fire would have all the fuel it wanted and plenty of oxygen.

Atmospheric Monitoring System Studies

The early-warning fire detection systems, as they are called, have been the subject of our studies over the past 10 years. As I stated earlier, tests in the early 80's showed that fires at low air velocities give a warning, prior to the appearance of visible flames, caused by frictional heating, while high air velocity fires flame before the warning. High air velocities actually hide a fire from an Atmospheric Monitoring System during its incipient stages because of the carbon monoxide delusion factor present at high air velocities. A fire would need to be much larger and consume more fuel during burning for there to be a warning of that fire. The original intent of the A.M.S. was to warn miners early enough to escape a fire before they are endangered, and to detect a fire early enough to extinguish the fire prior to major property damage and without jeopardizing mine rescue team workers.

In my opinion, the philosophy shared by the Bureau of Mines and MSHA today is, don't worry about early warning or a smoke-filled atmosphere when a fire occurs. They (the Bureau and MSHA) now are focusing on the ability of high air velocities to dilute the smoke-filled atmosphere in hopes that the miners find their way out before the fire becomes fuel-rich and high concentrations of carbon monoxide are encountered.

Another example of a smoke-filled atmosphere is the Wilberg Mine fire. There were 28 miners on the 5 left section on December 19, 1984. One of those miners found his way out of that section; many others tried the very same route but were not successful. If those miners would have had visibility, I believe there would have been others that would have survived that disaster.

In the beginning, A.M.S. sensors were spaced at 2,000 ft. intervals and many systems are approved at those spacings. Now, in 1989, studies show that the spacing should

be at 1,000 ft. intervals. MSHA is now requiring 1,000 ft. spacings on new approvals but not on existing approvals. All of these sensor spacing studies were conducted at air velocities of 125 fpm and 200 fpm and were performed with a flaming fire and not the smoldering fire with which most belt conveyor fires start. The proper way to determine the effectiveness of the A.M.S., requiring the system to give an early warning, would be to start the fire with frictional heating or the equivalent in a coal pile. On June 27, 1989, I observed two demonstrations at the Bureau of Mines Lake Lynn facility. The first test was for belt flammability and did not include a carbon monoxide reading. I personally paid special attention to those levels of carbon monoxide throughout the demonstration, because the test was using a coal pile with heaters and the air velocity was 300 fpm. This test excluded many combustibles that would be in a coal mine conveyor belt entry, but it was a test which was, in my opinion, more effective than present documented studies that use a flaming fire to start at the conveyor belt. The following are the readings of those carbon monoxide levels in time:

1. 0 minutes - turned on heating in the coal.
2. 21 minutes - smoke was visible and only 2ppm CO.
3. 22 minutes - flames were visible and only 3.2 ppm CO.
4. 24 minutes - flames were visible and 10 ppm CO.
5. 30 minutes - flames were visible and 15 ppm CO.

This demonstration, in my opinion, would be similar to a belt drive fire and shows how the A.M.S. would react to such a fire. The belt drives are required to have a sensor within 100 feet downwind of the drive. In this demonstration the sensor was located within 90 feet downwind of the origin of the smoldering fire. As you can see, at 300 fpm there would not be an early warning of a fire.

The second demonstration on this day was discontinued because all of the carbon monoxide sensors malfunctioned, but a video was shown of a prior test. The purpose of this demonstration was to show the effectiveness of an A.M.S. and the sensor spacings. The air velocity in this test was 125 fpm, with the sensor located 900 feet downwind of the fire source. The source of the fire was similar to frictional heating, utilizing a heater in a coal pile. The results of the test revealed that the sensor located 900 feet downwind detected 10 ppm carbon monoxide after the coal pile was flaming. I believe that, if a sensor was located approximately 100 feet downwind of the fire source, there might have been a warning prior to flaming.

The use of smoke detectors in conjunction with carbon monoxide sensors will, according to studies, increase the response time to a fire, but I don't believe based on present studies that they will provide early warnings of a fire at high air velocities. The smoke detectors will enhance activation of alarms when only belt slippage is involved and there are no other combustible materials. Presently a belt could slip and fill the entry with smoke, and no carbon monoxide could be present.

We have had A.M.S. in diesel mines since approximately 1985, with numerous nuisance alarms occurring because the diesels emit carbon monoxide. Operators have tried time delays, higher settings of alarms and tracking systems without success. The answer is the diesel discriminator which has been developed by the Bureau of Mines. Unless MSHA requires the diesel discriminator to be utilized, the manufacturers will not have an incentive to mass produce this technology and thus eliminate the

unnecessary alarms.

Another example of A.M.S. failure occurred in a mine in Pennsylvania that had several belt fires or heating incidents in a 4-month period. The A.M.S. did not activate a warning or an alarm during any of the incidents. This mine had as much as 250 fpm air velocity in the belt conveyor entry. During one of the incidents an employee found the fire on a tail roller of the drive. This employee extinguished the fire and the A.M.S. never activated a warning or an alarm. The sensor was located approximately 200 feet downwind. During the investigation the sensor was found to be properly calibrated and working with a known mixture of carbon monoxide. My only conclusion was that the A.M.S. was working properly, but because of the dilution factor the required warning level of carbon monoxide was not present.

Another example is the Marianna Mine fire. On the evening of the fire, testimony revealed that 120,000 cfm of air at a velocity of approximately 1,000 fpm was in the belt conveyor entry. Approximately 1 hour and 15 minutes prior to encountering the fire, three alarms were encountered within a 38-second period. These alarms were disregarded as false alarms. When the A.M.S. did alarm and was determined to be a true alarm, the point-heat-type sensors alarmed and the section was engulfed in smoke. All the miners inby the fire had to escape in a smoke-filled atmosphere. We, the industry and those miners were lucky on that day, but several days later, their luck ran out because the Marianna Mine was sealed. Now an operator has lost a major investment, the miners are unemployed and the community of Marianna is devastated by the after-effects of the sealing of the mine.

Several months ago I met with the MSHA investigators to seek out some information on that fire. When I asked if their report would address high air velocities and their effects on the fire, their reply was "We considered addressing the air velocities but decided against it," and therefore air velocity was not addressed in their preliminary report. When asking about the performance of the A.M.S. during the fire, their reply was "records indicate that it worked." I have spoken with numerous mine rescue team members that were at the Marianna Mine fire and all of them felt that the reason the fire got out of control was because of high air velocity. What is upsetting is that approximately a year and a half has gone by without a report from the Mine Safety and Health Administration, and these questions remain unanswered while additional approvals are being issued.

Miscellaneous A.M.S. Operational Deficiencies

1. Alarms on sections are not always heard or seen, especially on longwall retreat sections because of the 150 foot rule from pillar workings; permissible strobe lights and audible alarms are available but not required by MSHA.
2. Sensors are susceptible to moisture and dust.
3. Failure to alarm occurs with belt slippage or belt rubbing of non-combustible material.
4. A calibration drift occurs when system is operating on a battery.
5. Sensors react to diesel particulates and do not distinguish between carbon monoxide from fires and diesel.
6. Damaged data lines result in erratic readings.
7. Lengthy cable runs result in undetected errors.
8. Malfunctions occur in the system due to electrical problems.
9. Electromagnetic noises result in erratic readings.

10. Keying of trolley phones results in erratic readings.
11. Floating sensor heads have resulted in high alarms.
12. Failures occur in system power packs.
13. Low batteries result in incorrect readings and alarms.
14. System needs alarms when going onto battery.
15. No warning occurs when there is a loss of computer power.
16. Inadequate maintenance programs exist.
17. Sensors react to welding, cutting, and burning.
18. There is complacency among miners due to numerous false or nuisance alarms. Miners are not being withdrawn when alarms are activated.

These system deficiencies represent only a partial list. The UMWA has identified 52 deficiencies with the A.M.S. To date, most of these continue to exist throughout our nation's coal mines.

On October 25, 1988, the UMWA attended a meeting arranged through the Mine Safety and Health Administration at the Approval and Certification Center. The meeting included numerous entities of the coal industry, including A.M.S. manufacturers. The UMWA identified all of their concerns and the system deficiencies which they have collected from the A.M.S. surveillance program.

At this time, very little has come out of the meeting except for the notes. During this meeting the manufacturers were challenged to pick a mine, any mine of their choice, and we would review their computer printouts for a thirty-day period for system failures, warnings and alarms. At that time and since then, we have not had any takers accept our challenge.

Conclusion

The UMWA supports the use of the Atmospheric Monitoring System, but at this time it should only be utilized in conjunction with our present protections. For almost 10 years now, the A.M.S. has been utilized to replace protections provided to the miners, and the systems have not been proven to be reliable. Research and enforcement agencies only address the positive aspects of the systems and ignore the negative portions of those same systems. In reviewing studies made prior to 1969, in the early 80's, and the late 80's, it is my opinion that they have conflicting information. In years past, a proven method of controlling fires in belt conveyor entries was utilized. This method was to limit the air velocity, to separate the entry to minimize the spread of fire and to protect the miners from the by-products of fire. If this proven method was continued and the miners were to be warned without nuisance alarms of a fire in its incipient stages, the A.M.S. would be a major improvement over the point-heat-type sensors.

The UMWA wants the miners to have early warnings of fires, and these warning should be during the incipient stages of a fire if possible. We want the miners to escape areas of the mine inby a fire in fresh air and before the fire is out of control. At the same time we want fires to be encountered as early as possible in that the fire can be extinguished without physical or property damage. We have observed mines in this nation that have more velocity and higher pressures in their belt conveyor entries than the primary or intake escapeway entries. Just imagine if this was the case and a fire was to occur in the belt entry, as it did at the Marianna Mine. All entries would be smoke-filled and miners would have no choice but to escape in that environment.

I have hopes that the UMWA someday can convince those who are

controlling this movement toward disaster to back off before that disaster becomes a reality.

In the meantime, operators with concern for their employees and/or investment should move ahead with caution to assure themselves that high air velocities are what they want or need.

As for the A.M.S. and its operational deficiencies, most can be corrected if a manufacturer wants them to be, and if the operator properly maintains and installs the system.

TECHNICAL SESSION THREE:
REGULATORY DEVELOPMENTS, a panel discussion

Panelists:

Mark G. Ellis
Counsel
American Mining CongressWashington, DC
"The Regulatory Arena: Terms of Engagement"

Joseph A. Main
Administrator
Department of Occupational Health and Safety
United Mine Workers of America
Washington, DC

Patricia W. Silvey
Director, Office of Standards
Mine Safety and Health Administration
Arlington, Virginia
"MSHA's Recent Regulatory Activities"

Robert L. Vines
Vice President, Health and Safety
Bituminous Coal Operators' Association
Washington, DC
"Opening Remarks"

Bruce H. Watzman
Vice President, Safety, Health and Human Resources
National Coal Association
Washington, DC
"MSHA's Imbalance"

THE REGULATORY ARENA: TERMS OF ENGAGEMENT

Mark G. Ellis

American Mining Congress

I want to thank the program committee for inviting me to participate in this panel discussion on regulatory developments. As you can see from the composition of the panel, the committee members are keen observers of how the regulatory process works in Washington. It takes three representatives of the coal industry to balance the impact of the United Mine Workers on the Mine Safety and Health Administration (MSHA).

MSHA is not the only place that organized labor exerts its considerable influence, even though it is the federal agency responsible for establishing and enforcing mine safety and health standards. There is another, more powerful, forum available to them. I am speaking now of the U.S. Congress. But I am getting ahead of myself.

To understand the "terms of engagement" in the regulatory arena, you have to understand a little basic civil procedure. The Federal Mine Safety and Health Act of 1977 (the Mine Act) authorizes the Secretary of Labor to issue such regulations as he or she deems appropriate to carry out the provisions of the Act. In other words, Congress delegated to the Secretary, and through the Secretary to MSHA, the authority to implement the Mine Act as he or she sees fit. Congress also specified the procedures the Secretary should follow in issuing mandatory safety and health standards, including notice and comment rulemaking, petitions for rulemaking and recommendations of an advisory committee. Finally, Congress provided that any person adversely affected by a mandatory safety and health standard issued by MSHA may challenge the validity of that standard in a U.S. Court of Appeals.

MSHA is staffed with *many* dedicated professionals who develop the *many* mandatory safety and health standards and enforce them in the field through their *many* inspections. By and large they do a good job in their rulemakings, sometimes exceeding the bureaucratic "fully successful" job performance rating. The fact is that the mining industry, the miners and the American people want safer, more productive mines,and support MSHA's mission.

There are regulations on MSHA's books, however, that are vague and outdated. Neither the mining industry nor organized labor has been shy about bringing these perceived regulatory deficiencies to MSHA's attention. One factor that has separated our respective approaches to regulatory reform in the past has been adherence to the concepts of notice and comment standards development.

No doubt you are aware that MSHA is in the process of preparing proposed regulations for the approval and use of diesel-powered equipment in underground coal mines. Most people assume those draft mandatory safety and health standards will largely reflect the recommendations of an advisory committee initiated at the request of the United Mine Workers. As I understand it, those regulations will be out fairly soon.

One of the advisory committee's chief concerns was whether diesel particulate is a possible human carcinogen. Probably the most difficult question addressed was what occupational exposure level is appropriate for diesel particulate. Due to a lack of convincing evidence to establish an exposure standard and the lack of a reliable means to sample for diesel particulate, the advisory committee recommended that the current 2 mg/m^3 dust standard include the particulate produced as part of diesel exhaust. The advisory committee further recommended that the Secretary of Labor proceed to determine if a specific diesel particulate standard is warranted and should be established.

However, the labor organization that requested formation of the advisory committee was not content with its recommendations on diesel particulate. It also was not content with the regulatory "terms of engagement" provided in the Mine Act. Before MSHA put its proposed regulations out for public comment, the union went to its friends on Capital Hill and asked for oversight hearings on the health effects of exposure to diesel fumes in confined work places.

The hearings were held. Organized labor trotted out its witness panels and the federal research and safety and health agencies; the National Institute for Occupational Safety and Health (NIOSH), the Bureau of Mines, the Occupational Safety and Health Administration (OSHA) and MSHA were called in to testify. No new evidence surfaced in the hearings that had not been considered by the advisory committee. So what was the purpose? Have *you* ever appeared before a Congressional oversight committee? The whole purpose of the exercise, in my opinion, was to go outside of the regulatory process and put political pressure on MSHA regarding the particulate issue.

The road show of hearings held by MSHA on its proposed ventilation standards for underground coal mines is another example of politics and political organization obscuring the technical merits of an issue. The hearings degenerated into street theatre. Unfortunately, the United Mine Workers earlier had submitted extensive written comments on the ventilation proposal. I disagreed with much of what they had to say, but they did represent good technical comments from one segment of the mining community. Those comments, in addition to the technical comments submitted by the American Mining Congress (AMC), the Bituminous Coal Operators' Association (BCOA), the National Coal Association (NCA) and others, should be entitled to objective analysis if such objective analysis is still possible.

The point I am trying to leave you with this afternoon is that there are "terms of engagement" in the regulatory arena. Safety and health regulation today is very technical. The mining community cannot afford to have safety and health politicized. MSHA's mandatory safety and health standards, in order to accomplish their legitimate objectives, must be founded on sound technical evidence, not political persuasion. That is the essence of notice and comment rulemaking.

MSHA'S RECENT REGULATORY ACTIVITIES

Patricia W. Silvey

Director, Office of Standards

U.S. Mine Safety and Health Administration

Over the past several years, MSHA has devoted considerable resources to a comprehensive review of the Agency's existing technical and work-practice standards. The purpose of this review is to identify and remove standards that are irrelevant, conflicting, or outdated; to minimize reporting and recordkeeping burdens; to include compliance alternatives when possible; to upgrade requirements consistent with advances in mining technology; and to address hazards that are not presently covered by regulations.

With regard to mining technology, MSHA recognizes that advances in technology continue to result in new and improved mining methods, which, in turn, provide increased safety in the mining workplace. The agency realizes that technology not now envisioned may at some time in the future provide even more benefits; in revising the regulations we must be careful not to preclude the application of new technology, thereby preventing or delaying these improvements to the health and safety of the nation's miners. The Agency also recognizes that we must play an active role in the movement of technology which may not be fully developed, but looms on the horizon. In the area of equipment approvals, which of necessity are more specification oriented, we are now including in some proposed rules a "new technology" provision which applies to either new technology or new applications of existing technology. In drafting regulations, MSHA attempts to set performance-oriented requirements where possible. One of the benefits of performance-oriented standards is that they more readily accommodate new technology than do specification standards.

The Agency is also concentrating on improved health regulations and expects that this broad regulatory effort will result in significant improvements to the health protection provided miners. The health initiatives will also implement important statutory provisions (such as right-of-access to exposure records and transfer of miners for certain medical reasons). The proposed rule for Air Quality, Chemical Substances, and Respiratory Protection

Standards would revise MSHA's existing standards for air quality and chemical substances at both coal and metal/nonmetal mines. It contains permissible exposure limits for substances that may pose health hazards at these mines, requirements for controlling exposures, exposure monitoring, carcinogens, and respiratory protection programs. These revised health standards would be codified in a new Part 58 for metal/nonmetal and a new Part 72 for coal. This regulatory project would also update MSHA's existing asbestos standards.

The Agency published exposure limits for hazardous substances based on ACGIH's 1989-90 "TLV Booklet" and the exposure limits recently promulgated by OSHA, some of which are consistent with NIOSH recommended exposure limits. Under Section 101(a)(6)(A) of the Mine Act, MSHA must consider the latest scientific data, the feasibility of the standard, and the Agency's experience gained under the existing standards, as well as from other health and safety laws, in setting exposure limits to protect miners. The Agency's proposal also contains regulations for medical examinations for miners exposed to carcinogens when evidence indicates that early detection of health problems would be beneficial to the miner in terms of longevity or outcome. The Agency is also assessing the appropriate roles of engineering controls and respiratory protection in the prevention of occupational injuries and illnesses, and is proposing monitoring requirements to determine exposure to airborne substances.

As most of you know, MSHA's regulatory agenda covers a number of important subject areas. I will delineate several of the most significant in some detail and then briefly provide the status of others.

We are continuing our work on revising the existing ventilation regulations. With the announcement of the findings of the Belt Entry Review Committee (Review Committee), the Agency has reopened the ventilation rulemaking record. While the Review Committee worked independently of the ventilation regulatory effort, a number of its findings are relevant to the rulemaking issues. To the extent that findings are relevant, as noted in the Agency's notice announcing the availability of the Report, we are seeking the public's comment. Comments are due by September 25, 1989.

MSHA is proposing criteria and procedures for identifying mines with a "pattern of violations" of mandatory standards that significantly and substantially contribute to safety or health hazards. The proposed rule would implement Section 104(e) of the Mine Act. This provision was established by Congress to bring into compliance mine operators who ignore the intent of the law by establishing a record of repeated cycles of "violation, citation, and abatement," allowing significant violations of standards to occur, resulting in serious safety or health hazards. Under these regulations, MSHA would issue a pattern of violations notice to mine operators in instances where other enforcement efforts have failed. Once this Section 104(e) notice is issued, any inspection within 90 days that reveals another S&S violation would result in an order to withdraw all persons from the affected area until the

violation is abated. Withdrawal orders would continue to be issued for subsequent S&S violations until an inspection of the entire mine reveals no more S&S violations. The proposal contains a statement of purpose, a screening procedure for initial identification of mines that may be developing a pattern of violations, criteria for determining whether a pattern of violations exists at a mine, notification procedures with an opportunity for both the mine operator and miners' representative to respond, and criteria for termination of a pattern notice. The comment period on the proposed rule was extended until August 31, 1989, in response to requests from the mining community. Requests for public hearings have been received and the dates and locations for these hearings will be announced later.

In December 1987,the Secretary of Labor appointed an advisory committee to review standards and regulations related to the approval and use of diesel-powered equipment in underground coal mines. In July 1988, the committee recommended to the Secretary of Labor that diesel equipment be approved for use in underground coal mines and that standards be developed to address the safety and health aspects of use of such equipment. Over the past decade, diesel-powered equipment has been introduced into the underground coal mining industry in increasing numbers; at present approximately 100 underground coal mines are using about 1,400 pieces of diesel equipment. The proposals are intended to provide protection against explosion, fire, and other safety and health hazards related to the use of diesel-powered equipment. The proposed rules would also seek to amend certain existing safety standards that are now applicable only to electric-powered equipment so that such standards would apply, where necessary, to diesel-powered equipment as well. With respect to the health issue, diesel exhaust is composed of many different gaseous substances, as well as particulates, which may cause adverse health effects. MSHA's proposed rules would establish new requirements for the approval of diesel engines and other related equipment used in underground coal mines, establish exposure monitoring and reporting requirements for air sampling of gaseous diesel emissions by coal mine operators, and provide safety standards for the use of diesel-powered equipment in underground coal mines. The diesel proposal has just cleared OMB and should be in the Federal Register by the end of September.

The Agency is working on several other regulatory packages that affect the coal industry. We are developing a hazard communication proposal applicable to both coal and noncoal mines to reduce the incidence of chemically related illnesses and injuries in mining. This is still in the Agency, but is scheduled to go for Departmental approval at the end of September, with publication in the Federal Register anticipated sometime later this year.

Electrical systems used to operate most of the equipment in underground coal mines have become increasingly complex over the past 10 years, delivering higher voltages and creating the potential for more electrical accidents. Proposed rules on the use of electricity in underground coal mines, which reorganize, clarify, and update

existing electrical safety standards, are currently under review at OMB and we hope to publish these within the next several months.

The final rule revising MSHA's existing safety standards for explosives and blasting in underground coal mines was published in November 1988. The Agency plans to re-propose portions of these safety standards in response to comments from the coal mining industry received prior to the January 17, 1989, effective date of the rule. The re-proposal should be published early this fall.

The final rule for testing and approval of multiple-shot blasting units used underground in coal mines and certain metal and non-metal mines is presently under review at OMB. This rule revises 30 CFR Part 25. As Subpart D to Part 7 (Underground Mining Equipment; Product Testing by Applicant or Third Party), this final rule allows that blasting units be tested by the applicant or a third party selected by the applicant.

The proposed changes to 30 CFR Part 44, Rules for Petitions for Modifications of Mandatory Safety Standards, were published May 5, 1989. The comment period closed on August 7, 1989. A public hearing has been requested, and notification will be forthcoming on when and where public hearings will be held.

The existing roof control regulations were challenged in court,and on August 31, 1989 MSHA will issue a proposed rule addressing the quality of roof bolts and the removal of permanent roof supports (two of the three standards which were subject to court review). Under the Court's ruling, the existing standards will be vacated on February 15, 1990. To assure no gap in protection of miners, this rulemaking will proceed on an expedited basis. It is our goal to have the rulemaking finalized before February 15, 1990. The Agency has already scheduled a public hearing to be held on October 19, 1989, in Lexington, Kentucky.

We are reviewing comments on the Agency's reporting and recordkeeping requirements in Part 50 and anticipate a proposal by the end of this year. We will also begin early regulatory work on making improvements to our noise regulation and to our requirements for workers in confined spaces.

We appreciate your participation in our rulemaking process. We view your participation as an index of the importance which you place on the Agency's regulatory activities. To the extent that your comments, opposing or supporting, can be accompanied by specific rationale and/or alternative regulatory provisions, we are most appreciative.

OPENING REMARKS
for the
Panel Discussion on Regulatory Development

Robert L. Vines
Vice President
Health and Safety
Bituminous Coal Operators' Association, Inc.

August 30, 1989

Once again, we find ourselves in a forum composed of representatives of the various mining industries, the United Mine Workers and MSHA. As we all know from previous conferences, the eleventh commandment requires that such a situation calls for some serious MSHA-bashing. So as not to disappoint Pat Silvey, or the audience, I expect to do my share. But first, I would like to discuss some of the basic principles which should apply to health and safety regulation in the mining industries.

Basic Principles of H & S Regulation

The "commerce clause" of the Constitution gives the Congress power to regulate interstate commerce. In the 1969 Coal Mine Act and the 1977 Amendments, Congress made a number of findings, including (1) that the existence of unsafe or unhealthful conditions and practices in mines is a serious impediment to the growth of coal and other mining industries and cannot be tolerated, and (2) that the disruption of production and the loss of income by operators and miners as the result of accidents or occupational illnesses unduly impedes and burdens commerce.

As the result of those findings, the Congress adopted interim mandatory standards and empowered the Executive Branch with authority to adopt improved mandatory standards which would apply to all mines, the products of which enter or affect commerce.

The procedures for adopting improved mandatory standards are set out in detail and are intended to provide all interested parties a fair opportunity to present their facts. That opportunity has been used, of course, to present opinions as well as facts.

Industry Attitude Toward Safety Regulation

The effect of the 1969 and 1977 law has been a very positive one. The law and the standards are not perfect but they are not all that bad either. They have been an important adjunct to the industry's ability to maintain a constantly improving trend in safety performance. The standards, when properly enforced and applied, set a floor for safety below which no one should be allowed to compete. In consideration of the public interest, they establish the minimum level of safety to which all of our employees deserve to be entitled. If we did not have the law and the

regulations it would be even more difficult for conscientious operators to survive in today's competitive economy.

The challenge to solving the problem identified by the Congress can easily be translated into the following terms: The industry must meet the nation's demand for coal, domestic and export, with the fewest number of fatalities, personal injuries and occupational illnesses which can be managed. Any analysis of injury statistics over recent years reaches the irrefutable conclusion that the most successful measure for solving the problem is through the removal of people from risk. This may be approached in a number of ways, but basic to all of them is increased productivity--to meet the demand for coal while exposing fewer people to the inherent risks of the industry. Those persons who are exposed should be provided adequate protection by both the mining equipment and hardware and by the mining process and practices. This is where mandatory standards play a vital role in ensuring that feasible protections are required. In general, MSHA has developed a very sound set of standards over the years, but there are serious pitfalls which must be avoided. Regulations can be counterproductive. If they result in more exposure to risk than the exposure they are intended to avoid they will detract from safety performance. There is a tendency at MSHA not to take that factor into consideration. Whenever that happens, you will find the industry vigorously opposing any proposal which we believe does not improve safety.

Another situation in which a standard may be counterproductive to safety is whenever it places a heavier burden on a particular mining system as compared to another. For example, if a standard were to be selectively restrictive to a high-productivity mining system, such as longwall, it could result in fewer longwalls being employed and the demand for coal being met by mining systems which expose more people to risk. The inevitable result would be more fatalities and injuries because the same amount of coal is going to be produced, regardless the mining system by which it is produced.

How Does MSHA Manage its Rulemaking Function?

As a general observation, MSHA does very well in its rulemaking function. However, this is the time for MSHA-bashing so we must take a look as some of the real screw-ups, and sometimes MSHA is pretty good at screwing things up, too.

One example of this that comes to mind is MSHA's only use of its authority to adopt an emergency temporary mandatory standard. Congressional oversight hearings on the agency delved into, among other things, the fact that self-rescue devices were not timely or properly used following discovery of the fire at the Wilberg mine. A more dispositive result of the hearings was the political judgement on the part of elements of the Senate Committee that said Committee must get credit for forcing MSHA into some drastic, highly-visible action that plausibly is responsive to the Wilberg disaster. A bright young Senate staffer, upon learning that the mining act contained a provision for adoption of a temporary emergency standard, struck upon the idea of using it to adopt a standard requiring hands-on training the for use of SCSR devices. MSHA wimped out in the face of the Senate suggestion--and for the first and only time adopted a temporary emergency standard. Under law, such action is reserved for use when miners are exposed to grave danger from hazards and such an emergency standard is necessary to protect them from those hazards.

Hands-on training is good for more applications--certainly for donning self-rescuers, and BCOA, speaking for its member companies, supported the permanent standard on its merits. We believe, however, that MSHA misused its rulemaking authority and discredited itself in adopting it as an emergency standard. There was no emergency, and none arose during time the emergency standard was in effect. The agency lost credibility throughout the coal industry.

Another bash which MSHA has earned flows out of its willingness to schedule predictably repetitive hearings at sites all over the country in order to satisfy the political strategy of the UMWA. A case in point is last year's series of hearings on MSHA's proposed ventilation standards, which were arranged so as to accommodate the Union's publicity-seeking tantrum--which was disguised as evidence. MSHA has an extremely serious duty to gather all of the pertinent facts, sift them out, and come up with a standard which serves the public interest. It should not allow the process to be corrupted by a strategy which is designed to intimidate its decision-making process by a demonstration of political power, and by its ability to orchestrate the actions of large numbers of people.

BCOA chose to present its testimony at a single site in a factual, unemotional way. We believe that regulations should not be written at the carnival and MSHA should not entertain a carnival atmosphere.

Still another rulemaking-related exercise for which MSHA should be less than proud is its drafting of Regulatory Impact Assessments and Regulatory Flexibility Analyses--commonly referred to as "Regflex" in Beltway vernacular. These analyses are required by law to provide some degree of assurance of a favorable cost/benefit relationship for government-imposed rules. I don't recall ever having seen one which served that purpose in any meaningful way. Usually, these documents are merely an exercise which miss the target by so much that one must wonder whether anyone really was aiming at it.

A horrendous example is the "Regflex" prepared to accompany the proposed rule for Pattern of Violations. This document, obviously prepared by some learned people, perhaps Ph.D's, commingles some production data, work-time records, corporate profit-loss statements, injury frequency records and numerous strange assumptions in order to evaluate the benefits and the costs of the proposed rule. The benefits? You will be pleased to know that a minimum of 0.105 and a maximum of 0.427 fatalities will be prevented annually at those mines issued pattern notices. The costs? You also will be pleased to know that the total cost to mine operators or their customers will range from a minimum of $30,500 to a maximum of $109,400 annually. If there is anyone here who does not believe this is pure garbage, please see me after this session--there is a nice, big bridge across the East River I would like to sell you.

This is an example of a law intended to serve the public interest which, in practice, does nothing more than mislead the public and waste the time and effort of the agency's people.

Thanks for your attention. I hope that I have given you some food for thought.

MSHA'S IMBALANCE

Bruce H. Watzman

Vice President Safety, Health & Human Resources
National Coal Association

If a decision was made to appoint a public interest group advocate as the Assistant Secretary for the Mine Safety and Health Administration, what would that person seek to accomplish? Certainly, like any other individual holding that position, the first goal would be to improve safety and save lives. His second goal, however, might well be to further the interest of labor and the causes of his "public interest" group.

He could accomplish these latter goals in a variety of ways. First, he would seek tremendous increases in the level of enforcement activity. Second, he would undoubtedly attempt to expand the rights of "miner representatives" and the circumstances under which the rights could be exercised. Third, he would seek to expand opportunities for compensation for miners during non-productive time. Fourth, he would attempt to delay the introduction of productive equipment that could mean lower labor costs per ton of coal mined. Fifth, he would attack the industry's safety record, in an effort to support the achievement of these other goals. Finally, he would seek to overturn policies and legal precedents favorable to the industry's position, that inhibit the achievement of these goals.

The bureaucracy at MSHA, through the action or inaction, intentional or unintentional, has been moving forward in pursuit of the accomplishment of each goal that I have just outlined. The facts speak for themselves.

During repeated, record-breaking safe years for the industry, achieving the lowest number of fatalities, and fatalities per man hour worked in history, MSHA has targeted Part 50, accident reporting, as an enforcement priority. While the regulations and their guidelines have undergone massive changes in interpretation and emphasis, and are unquestionably complex and often illogical, the agency's focused Part 50 enforcement has detracted from our record-breaking safety achievements.

With this in the background, efforts at regulatory reform have been stalled. Standards that were promulgated twenty years ago, and based on technology that is at least twenty-five years old, continue to regulate the coal industry, and often prevent the introduction of new, safe, and more productive equipment.

Concurrently, the process of modifying standards on a site specific case, Petitions for Modifications, is in turmoil. An uncontested petition can take two years to obtain, and the union appears to be contesting every petition filed on an important issue at unionized operations. When contested, the petitions can take six years to finalize. Again, the result is a mine operator's inability to introduce new, safe, and more productive equipment or mining techniques. Even when petitions are needed because the standard results in a diminution of safety, during the last year MSHA has refused to allow the petition to go into effect immediately. While one part of the agency claims they cannot provide interim relief, due to a court decision, the Assistant Secretary in a federal register notice states that he retains the authority to issue interim relief when a diminution of safety

resulted in the issuance of a temporary restraining order against MSHA by a federal district judge, and more can be anticipated unless interim relief again becomes available to solve serious safety problems.

On the enforcement side, proponents of increased activity need not worry. The total number of citations, and more importantly, the number of unwarrantable failure citations and closure orders, is skyrocketing, due to MSHA's increased enforcement activity. In 1988, there were 160,000 citations issued, compared to 133,000 in 1987. Worse yet, there were 4600 unwarrantable failures in 1988, compared to 2800 in 1987. These numbers are particularly disturbing, since the industry's safety record was the best ever, and during this time frame the Review Commission redefined the term unwarrantable failure. It now means "aggravated conduct constituting more than ordinary negligence;" a much stricter standard than the old "knew or should have known" definition, that should have led to less, not more, unwarrantables.

These efforts have been suppo: ted, and perhaps led, by MSHA's lawyers, whose actions often seem at odds with established agency policy. For years, MSHA's lawyers have attempted to expand payments to miners for non-productive activities. In the training area, MSHA tried equally hard, but was not quite as successful. Repeatedly MSHA argued in court that miners should be paid for training, even when laid off or unemployed at the time they received the training. These arguments were rejected by the U.S. Circuit Court of Appeals, and just this month MSHA issued a policy memorandum reversing this long-standing policy.

Similarly, during the last two years there have been repeated attempts by MSHA's lawyers to expand closure order enforcement powers and overturn legal precedents that interfered with non-productive, miner compensation. One of the key triggering mechanisms for closure orders is the designation of a citations as "significant and substantial." This designation is required for an initial unwarrantable failure citation, leading to unwarrantable closure orders, and plays a key role in Pattern of Violations enforcement, a term currently undergoing rulemaking. An "S & S" designation also means the difference between a minimum penalty, and a potentially higher one.

Since the issuance of the National Gypsum decision in 1981, the MSHA lawyers have been striving to create "presumptions" that certain categories of citation were "S & S." Early this summer, in a proceeding involving Birchfield Mining Company, the agency argued that all preshift inspection violations were "per se" "S & S." Quick intervention by the industry resulted in MSHA reversing its position, endorsing the National Gypsum definition, and permitting the ultimate settlement of the case.

While these are a few of the more visible examples of the imbalance that seems to exist within MSHA, I am certain that a survey of mining operations would produce a host of similar, local examples. Naturally, neither the public interest groups, nor the unions would admit to the imbalance. In fact, they constantly strive to find examples on the other side of the equation. Unfortunately, these examples are hard to find.

When the industry achieves a safety goal, the achievement is founded on logic and sound reasoning and supported by the facts. Nevertheless, our accomplishments in reforming MSHA policies are infrequent and come only after lengthy delays or necessary court actions.

For a number of years the National Coal Association was not active in mine safety and health regulatory matters. In 1988, however, we created a safety committee and charged it with a pro-active approach to accomplishing both safety and regulatory improvements. We intend to be at the forefront of the industry's efforts to cure the imbalance. We will actively promote the cause of safety, vigilantly guard against the erosion of hard-fought gains, and relentlessly strive for the regulatory reform that our industry needs to enter the next century as a safe, productive and successful segment of the American economy.

BANQUET SESSION

S. O. Ogden, Chairman and Chief Executive Officer, Island Creek Corporation, Lexington, Kentucky

"Twenty Years - Past and Future"

TWENTY YEARS--PAST AND FUTURE

S. O. Ogden

Chairman & Chief Executive Officer

Island Creek Corporation

This marks the twentieth anniversary of the Institute on Coal Mining Health, Safety and Research - an institute created by VPI's own Dr. Dick Lucas and others to establish for the coal mining community a communications forum for the Federal Coal Mine Health and Safety Act of 1969. As we look back to 1969, we see an industry that produced 569 million tons of coal with a peak productivity rate of 2.6 tons/worker hour. However, in 1969, the industry also experienced 209 fatalities (.36 per million tons or one for every 3 million tons of production) and 9,917 lost time accidents (17.4 per million tons). Twenty years later in 1988, the industry produced almost 960 million tons with an estimated productivity rate of 3.5 tons/worker hour. In 1988, the industry experienced 52 fatalities (.05 per million tons or one for every 20 million tons produced) and 12,435 lost time accidents (13.0 per million tons). During the last 20 years, then, we have seen a 67% increase in production, a 35% increase in productivity, a 75% decrease in fatalities, and a 25% decrease in the rate of lost time accidents. These are significant statistics, statistics that reflect a tremendous effort by the coal mining community. And you have heard from different segments of our community as to how engineering, education, and enforcement have contributed to the successes of the last two decades.

It would be redundant to repeat those success stories again.

For the twentieth anniversary of the Institute, I have been asked to share with you what I see as the future of our industry for the next 20 years. But first let me take a few moments to summarize where we've been.

The coal industry has experienced tremendous change over the last 20 years,as have all industries. In addition to implementing the provisions of the Health and Safety Act of 1969, the 1970's began in earnest with an emphasis on environmental issues with the passage of the Clean Air Act of 1970, and

subsequent amendments in the latter part of the decade which mandated scrubbers on all new coal-fired generators. On the demand side, electricity growth was projected to be four-to-six percent per year,with the emphasis on low sulfur coals to meet air quality standards. Industrial demand for coal was growing and metallurgical demand was substantial. The outlook for coal exports was optimistic as was the coal demand for synthetic fuels development.

On the supply side, the production base of the industry was relatively small,with little to no excess. Metallurgical coal was in tight supply, and leasing and permitting delays for western supplies were holding back expansion in this region. Productivity was falling with adherence to the Health and Safety Act requirements, a young, inexperienced workforce, and wildcat strike activity, and the industry structure was more concentrated by captive utility and steel company producers.

The oil shocks of 1973 and 1979, aided by the 1978 Fuel Use Act which mandated coal capability in all large facilities to lessen dependence on imported oil, spurred all the major oil companies to diversify into coal. Massive capital investment was infused into the industry, resulting in a rapid expansion of productive capacity, particularly in the western producing districts.

As markets for coal expanded rapidly, primarily for use in power generation by electric utilities both domestically and internationally, optimism for the future expanded into international supply regions with aggressive development of coal resources seen in South Africa, Australia, Canada and Colombia, as well as the United States. The severe economic recession at the start of the 1980's quickly reversed the level of optimism held only a few years prior. As economies slowed, the world steel industry declined, and energy conservation and aggressive nuclear expansion to meet the overly optimistic projections of electric generation demand took their toll on all energy forms. Excess supplies of all fuel types occurred,which led to declining prices and profit levels.

As a result, the decade of the 80's has been characterized as a period of massive consolidation and rationalization throughout the world. Emphasis on productive mining technologies, training and educating the workforce, and closure of older, less-efficient mines, as well as consolidation of capacity through mergers and acquisitions, have led to a more stable operating environment and a safer, more attractive workplace in recent years. The current state of the industry, where supply and demand have come into better balance, has been aided by the sustained economic expansion in world economies over the past several years and improved labor/management relations in the coal industry--the latter being true, of course, until the recent disruptions by the UMWA arising from the current contract dispute.

In recent years, I have viewed the industry with increasing optimism. However, with the recent labor turmoil, enthusiasm for onerous acid rain legislation and concerns about global warming have tempered my views. The consolidation of the industry will continue to escalate in the coming years,

bringing with it greater stability and predictability for the coal business. Rapid expansion of supply will be tempered due to the negative experiences of the past, preventing a buildup of large excesses. Pressure to keep costs competitive,in order to effectively compete in international markets, will also prevent large price swings from occurring as in the past. However, growth in the world economy should offer good opportunities for coal producers,primarily from increased power generation, but also from more stable markets for the metallurgical coals needed to serve domestic and foreign steel industries. Prices must increase to levels which provide reasonable returns on the investment that will be needed to attract the new supply necessary to meet these market demands. Thus, profit levels should improve and enhance shareholder values.

Near-term, the coal industry will have to adapt to the inevitable push for greater control over the environmental impacts of energy use. Acid rain legislation will be enacted which will result in regional coal supply shifts and greater competition from natural gas. Increasing deregulation trends in the electric utility industry will also force coal producers to become more market oriented in order to meet the power generators' needs. Coal companies must be prepared to provide a competitively priced, high-quality fuel product on a secure and reliable basis.

On the operating side, the recent labor unrest has severely impacted the U. S. coal industry's efforts to become a competitive force in international markets. The past eight years have been dedicated to building a more favorable labor/management working relationship, and demonstrating to the rest of the world that the U. S. should be viewed as a dependable and assured source of supply for competitively priced coal. Expectations for regaining the export leadership role from the Australians and competing with the newest world competitors, Colombia and Venezuela, were an achievable objective. The reaction of foreign buyers is difficult to predict, but the recent situation has hurt the advances made to date.

Coal's competitiveness with other fossil fuels will continue to be enhanced with improvements in mining, processing, and combustion technologies. The productivity of longwall systems is accelerating and the ultimate capability of these systems will continue to be tested with further advances. Remote control control miners are at the leading edge of future robotics-types of technology, not only for improving productivity, but more importantly, for increasing safety.

Finally, to address the environmental concerns and still meet the world's energy requirements, research on clean coal technologies for combustion must be advanced to the commercial stage of development. Coal should be the fuel of choice in the longer term, in spite of some of the near-term uncertainty. Therefore, the next 20 years look very promising from a coal industry perspective. However, we must continue making improvements in the health and safety of our workforce. A fatality-free work environment is within our short-term sights. Coal workers'pneumoconiosis and hearing loss can and must be eliminated. In addition,

regulations must keep pace with technology, and there must be continued development in the methodology of training miners to work safely.

As we strain our present technological boundaries, research is needed to provide new mining technologies that will lead to safer and more efficient systems and meet the coal demand of the future.

In summary, our industry has made impressive improvements in the last 20 years. We face a bright future 20 years hence. Our real challenge is to manage the difficulties and uncertainties of the next several years while maintaining our progress toward better and safer mines.

TECHNICAL SESSION FOUR:
GROUND CONTROL AND ENVIRONMENTAL CONSIDERATIONS

Chairmen:

John McCormick
Chief of Safety Technology
Mine Safety and Health Administration
Pittsburgh, Pennsylvania

Harry Childress
Chief
Virginia Division of Mines, Minerals and Energy
Big Stone Gap, Virginia

"THE REAP PROGRAM - AN EFFECTIVE STEP TOWARD ROOF CONTROL SAFETY"

J. M. KRESE

ASSOCIATE ASSISTANT ADMINISTRATOR

MINE SAFETY AND HEALTH ADMINISTRATION

Figure 1.--REAP Logo

REAP -- Roof Evaluation and Accident Prevention. It's more than just a catchy name for a government program -- it's an important goal for our entire industry.

Falls of the roof and ribs are among the most serious of all the safety hazards facing the coal industry. Since the turn of the century, over 35,000 coal miners have lost their lives in roof fall accidents.

While injury rates in coal mining have greatly improved, roof and rib falls still remain the Number 1 cause of death in underground coal mines. Since April 1984, the REAP Program has worked to reduce these accidents within the industry.

This program is unique in that it is not just an MSHA-sponsored program. The program is jointly supported by both industry and labor, and other state and federal governmental agencies.

When you consider the need that existed, it is little wonder so many groups were willing to get involved and support this cause.

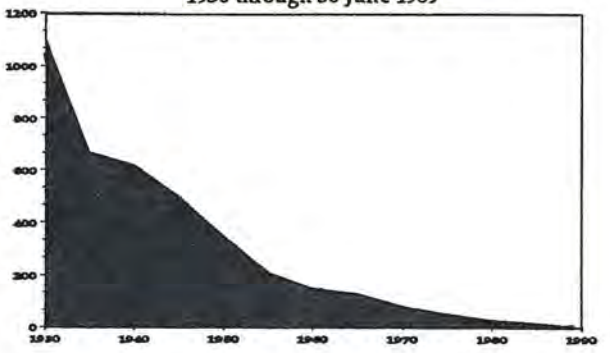
Look at the list of those groups or agencies that participated in the development of the program. They include the United Mine Workers of America, the American Mining Congress, the Bituminous Coal Operators' Association, the National

Independent Coal Operators' Association, the National Association of State Mine Inspection Agencies, the Bureau of Mines, the coal industry, and MSHA.

The representatives of these various groups are dedicated to doing something to slow, and someday hopefully stop, this cycle of death within our mines. Why are they so interested? Again, because they see the need.

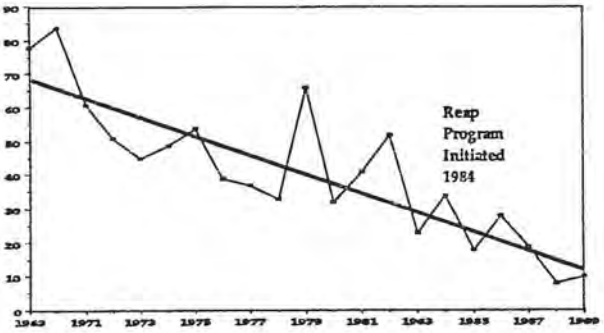
As I said earlier, despite improvements in injury rates in coal mines, falls of roof and ribs still continue to be the major cause of death in underground coal mines. Taking a look at historical data, we can see where this has always been pretty much the case.

Figure 2.—History of roof and rib fatals 1930 through 30 June 1989



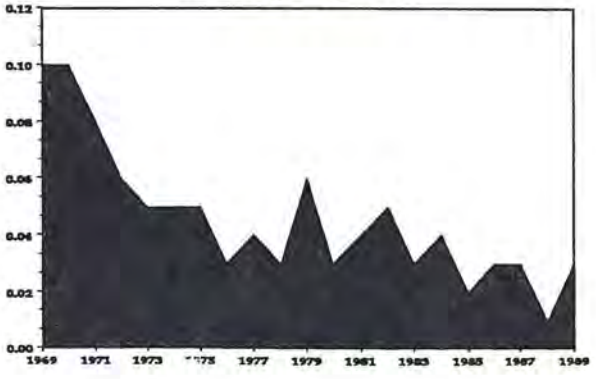
This graph shows roof and rib fall fatalities from 1930 through the present. We can see where we have gone from a figure of about 1,100 roof-and rib-related deaths in 1930, to, currently, 10 deaths this year. This is a historical trend graph and it does show that significant improvement has been made.

Figure 3.— Roof fall fatalities and trend 1969 through 30 June 1989



Moreover, if we look at this chart, which continues to show the historical trend line from the previous graph but also shows the actual number of roof fall fatals by year, we see that roof fall fatalities have somewhat followed the same pattern as other mine fatalities. Both mine fatalities in general, and roof fall fatalities in specific, have continued to show variation from year to year, but the overall trend shows a decrease in accidents.

Figure 4.— Roof/rib fall incidence rate 1969 through 30 June 1989



Likewise, the incidence rate for roof and rib fall accidents also shows quite an improvement since the enactment of the 1969 Mine Act. The rate has fallen from 0.10 in 1969 to 0.01 in 1988.

This is a significant drop, despite the fact that there still seems to be some variance in the degree of the improvement.

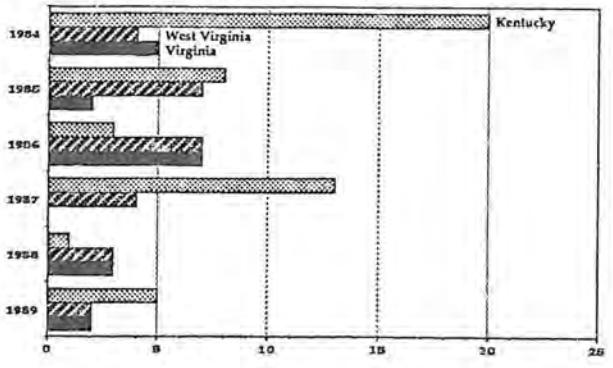
To me, this says that regulatory programs have definitely played a role in reducing roof fall accidents. However, if more substantial reductions are to be seen in this area, we must seek to expand into other "nonregulatory" areas.

On the average, roof fall fatalities account for approximately 46% of all underground fatalities. Our best year, percentage-wise, for roof-and rib-related accidents was 1988. That year, roof-fall deaths accounted for 32% of the total underground fatalities.

The record low number of roof- and rib-related fatalities came in 1988 with 8 such accidents nationwide.

Since we are looking at national statistics, it is appropriate that we identify where the majority of these accidents are occurring. This is where I stand to get myself into a little hot water, but I am sure that you are aware of the facts.

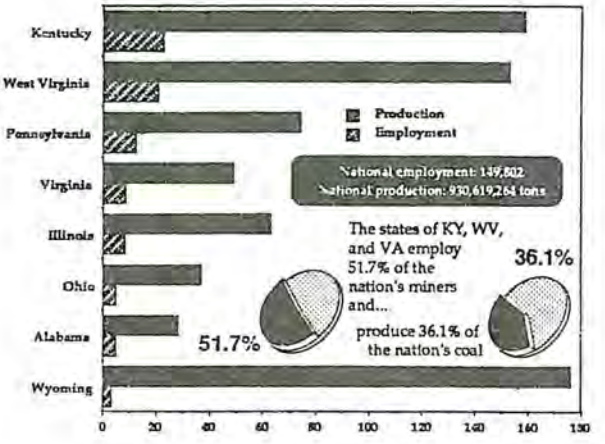
Figure 5.— Roof fall fatalities for Virginia, West Virginia and Kentucky 1984 through 30 June 1989



Three states consistently have the highest rate of roof fall accidents. These states are Virginia, West Virginia and Kentucky.

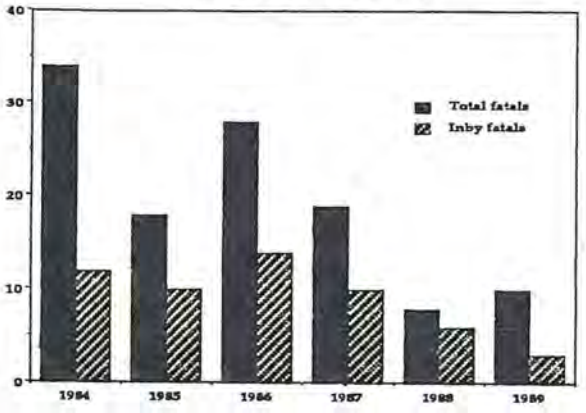
I do not mean to imply that these states are negligent in their pursuit of safer mines. This statistic simply means that, due to several circumstances working together, we still have a lot of work to do to make your mines safer from the threat of roof-and rib-fall accidents.

Figure 6.— Coal mine employment/production by state, 1988



What are these circumstances? As you can see, Kentucky leads the nation not only in production, but also in employment. The three states I have mentioned (Kentucky, Virginia and West Virginia) employ just over 50% of the nation's coal miners. With that level of employment, you can also expect that more miners are going to be exposed to the hazards associated with mining, thus bringing about higher accident rates.

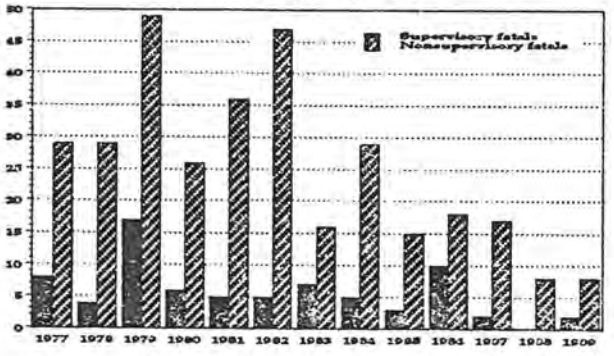
Figure 7.— Roof and rib and inby support fatals 1984 through 30 June 1989



Since I mentioned exposure to hazards, this seems like as good a time as any to deal out the bad news. Almost one-half, or 47% of all the roof fall accidents since 1984 can be attributed to one cause -- going beyond roof support.

To me, it is astonishing that we tell miners constantly from day one, not to go inby roof support. but that it continues to happen.

Figure 8.— Supervisory and nonsupervisory fatalities from fall of roof, face or rib 1977 through 30 June 1989



Roof and rib-fall deaths among supervisory personnel also seem to be extremely high. This is another area on which we need to concentrate. Historically, foremen have accounted for 18% of all roof- and rib-fall fatalities. This figure is somewhat contrary to what we would expect from our foremen. We depend upon them to be leaders in our mines. They have the most experience and have had special training to aid them in performing their duties safely. However, the sad fact remains that they continue to fall prey to roof- and rib-related accidents.

Also, it is important to identify when these accidents are happening. Throughout 1987 and 1988, the high months seem to be March, April, June, July and December. Are these statistics significant? They tend to support two ideas on why accidents occur. First they show a definite trend of accidents happening during a change in season. During this time of environmental change, the mine's roof becomes unstable, thus making roof falls more likely to occur.

Second, they could point to a behavioral trend. Summer months are traditionally vacation times, and December brings the holidays. There are those experts that are studying the effects of outside pressure upon the victims involved in mining accidents. Those people would say that the pressures associated with the family and the holidays or vacations could be a major factor in the rise of roof-fall related deaths during those periods.

Now that we have gone over what you probably already knew, let me tell you more about what the REAP Program is

doing to combat roof-and rib-related deaths in the nation's mines.

As I said earlier, the program first got underway in April 1984. We are now trying to breathe new life into the program. MSHA's role within the program should be that of a catalyst or motivator. The primary emphasis on the program should be spread evenly. All of the parties who were a part of the original charter should share in keeping the program alive and growing.

A key to the success of this program is awareness. As we saw in looking at the statistics, an alarmingly high number of roof-fall deaths occur because the victim went inby support. We must do something to impress upon our miners that "INBY IS OUT!" That is exactly the message that the REAP Program is taking to its audience through its logo. This message, and others like it, are aimed at keeping miners safe from the hazards of roof-and rib-related injuries by making them aware of the hazards as they exist in their working environment. The theory is that, once the miner is aware of the hazards, he or she will be able to perform assigned tasks in such a manner as to avoid potential accidents.

Our awareness-building program does not stop there. We have produced a set of country music tapes suitable for being played in bathhouses during changing hours. The goal of this project is to get the message out there by making use of this effective tool. The response to this program has been overwhelming, and we have a couple more sets of these tapes that will soon be on their way to the mines. We hope to expand upon that idea in the future.

We are also continuing to produce monthly posters with messages relating to roof and rib safety. These posters are designed to be used on company bulletin boards, and in other areas of the mine. Each month has a different message, but they all relate to roof and rib control. We have solicited ideas for posters from the industry, and we will recognize those people whose ideas are used.

These are just a few of the areas in which the REAP Program is currently involved. However, we also need to start laying a foundation on which the program can build for the future.

We are starting to look at the theory of barrier analysis. This concept studies mining fatalities and seeks to determine what type of barrier could have prevented a particular accident. This program classifies accidents into two categories. First, it identifies those accidents which could have been prevented by a physical barrier. Second, it identifies those accidents which could have been prevented by action on the part of the person involved.

Most of MSHA's activity is focused within this first area. The reduction in accident rates to this point, in the industry,can primarily be attributed to work that has

been done to reduce the physical hazards of mining.

However, now we find ourselves at a crossroads. To achieve further improvements in safety, we, as an industry, must begin to look into this second class of accident, those that could have been prevented by action on the part of the victim.

The theory of barrier analysis goes on to ask the question of whether, either consciously or subconsciously, we are rewarding employees for working in an unsafe manner. Conversely, are we punishing those workers who make safety a priority? Think about the priorities that you set for workers. Do the goals and objectives that you stress give your employees the idea that safety is to be the top priority, or could they somehow or otherwise perceive that your philosophy calls for them to produce, even at the risk of safety?

As an industry, we need to turn our focus and start taking the human element into consideration. We need to take a look at programs such as Dupont's "STOP" program which very successfully identifies and works to eliminate those accidents which can be avoided by action, not only on the part of the 1st line supervisor, but also the worker.

To be successful, we must continue and even expand the research that is being performed within the area of barrier analysis. The Bureau of Mines has done some studies on the subject, but more needs to be done. Some recent studies done by the Bureau include:

IC 9217, which centered on human factors contributing to ground-fall accidents in underground coal mines - worker's view,

IC 9151, which focused on roof-and rib-fall accidents and cost statistics: an in-depth study, and

IC 9182, dealing with human factors in mining.

To accompany the expanded research effort, we also need to continue with our emphasis on education and training.

We must continue to stress the basics, and also continue to develop new and specialized training programs to deal with specific problem areas when they arise.

The Department of Mines and Minerals people in various states have developed several specialized training programs, each dealing with specific hazards relating to roof and rib control. One such program was designed to alert miners to the roof-control hazards in low coal. Particular attention was given to auger-type continuous mining sections, following the Bon Trucking accident, which killed four miners in Harlan County.

These programs have definitely been successful and have had a positive impact on safety. We need to continue to expand upon these successes.

In summary, we all see the need for increased roof-control safety. The fact that 10 miners have died this year in roof-and rib-related accidents means that we have work to do. Well, you might say that we have made improvements, but 10 people dying is 10 people too many. We are on the right track and,as an industry, we can and will do better.

In our effort to do better, we must work together and share the responsibility of getting the message out there. Our major concern is to make miners aware of the hazards and to identify ways that they can perform their jobs in a safer manner.

ROOF SUPPORT SYSTEMS CONTINUE TO EVOLVE[1]

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INTRODUCTION

In response to the mining of reserves with increasingly adverse ground conditions and the roof support recommendations of current rock mechanics theories, roof support systems have continued to improve. Their evolution can be traced from the use of mechanically-anchored tensioned bolts in the 1950's, through the introduction of fast-setting resins during the 1970's, to the mechanically-anchored, resin-assisted tensioned bolts of the 1980's. This paper will concentrate on a variety of roof supports that have recently become available within these general classifications:

1. Mechanically-anchored, tensioned bolts

2. Non-tensioned, grouted bolts

3. Resin-anchored, tensioned bolts

4. Mechanically-anchored, resin-assisted bolts

Some of the newer systems represent a departure from previously used technology while others are refinements of supports that have been in use for several years. These systems have allowed for a safer and more economical recovery of coal reserves with adverse roof conditions. This paper will also address the friction-reducing washers and pressure gages used for the installation of resin-assisted tensioned bolts.

MECHANICALLY-ANCHORED TENSIONED BOLTS

Over 45 percent of the bolts installed underground are mechanically-anchored tensioned bolts, primarily because they can be installed quickly and are relatively inexpensive when compared to the other support systems. The expansion anchors come in a variety of sizes and shapes and can be classified under two types: bail type or standard type. There have been no innovations in the basic function of the expansion anchor; however, due to the continued use of these anchors with resin

[1]The roof support systems discussed in this paper have, whenever possible, been referred to in generic terms. Trade names are used only when necessary to describe novel products known to the industry by those names, and no endorsement on the part of MSHA is expressed or implied.

systems (mechanically-anchored, resin-assisted bolts will be discussed later), there has been a desire to use these bolts in smaller hole sizes (less than 1 3/8 inch). Most recently, three new expansion anchors have been developed for use in boreholes ranging from 1 - 1 1/8 inch (Fig. 1). While these anchors are primarily intended for use with resin systems, all three can provide a tensioning and anchorage capacity comparable to the larger anchors without the use of resin. Even though mechanical bolts remain the standard of the industry, they have limited application in adverse ground conditions.

NON-TENSIONED GROUTED BOLTS

Non-tensioned grouted bolts rank second in usage after mechanically-anchored bolts. With the development of fast-setting resins, fully-grouted bolts have become more popular and currently represent over 30 percent of the roof supports installed in underground mines annually. This system provides a stiff support; however, it is passive since it is not tensioned. The majority of the fully-grouted bolts installed consist of a No. 6 rebar. The most recent change in the area of non-tensioned grouted bolts has been the use of 2 No. 5 grade 60 rebar as a replacement for the notched No.6 grade 40 rebar (Fig. 2). Pull tests have demonstrated that a No. 5 fully grouted rebar provides anchorage comparable to a fully grouted No. 6 rebar. Because the No. 5 rebar is bendable without notching, it has a uniform strength throughout its length, unlike a notched rebar. More resin is needed to grout a No. 5 rebar and specially designed resin cartridges are now available for this application. To date several mines are using the No.5 rebar with favorable results.

RESIN-ANCHORED TENSIONED BOLTS

Resin-anchored tensioned bolts have made a major impact in controlling adverse roof conditions. Traditionally these systems utilized a length of grouted rebar to provide anchorage so that the bolt could be subsequently tensioned. This was accomplished in two different ways. Some systems used a coupling to connect a length of rebar to a mechanical bolt. The coupling contained a thread take-up inhibitor to allow the resin to be mixed prior to tensioning. The other type employed a threaded reinforcing bar with a torque-resisting nut (tension rebar nut) for mixing of the resin and tensioning. Two of the latest systems (Fig. 3) to enter the market represent a departure from the technology of the resin-anchored tensioned bolts used in the past. The first system, called the Cone Spiral bolt, consists of a threaded smooth bar with a forged cone at the top. To mix the resin, a length of wire wound around the bolt in a reverse helix is used. The wire is welded to the cone and to the bolt stock. A tension rebar nut is used to prevent thread take-up during the resin mixing cycle. Because the wire is wound around the bolt in a counterclockwise manner, as the bolt is turned clockwise it pushes the resin up towards the top of the borehole causing a violent mixing action. As the bolt is loaded, the cone at the top of the bolt pushes down on the resin column, causing it to compress in the hole which in turn strengthens the resin anchor.

The other system is the Fastorq bolt, which consists of a mechanical bolt with a tapered hex nut at the end. This bolt also utilizes a wire mixer, which is welded to the bolt and to the hex nut. To install this bolt, the resin is first mixed, and then after a short hold time the bolt is tensioned by turning it into the hex nut which is held in place by the resin anchor. To reduce the amount of torque required to tension the bolt, a hot-melt glue is applied to the bolt, wire and nut. A friction-reducing washer (which will be discussed later) is also used to reduce the friction

during tensioning. As the glue melts from the heat generated by the mixing and curing of the resin, it acts as a lubricant for the bolt as it is tensioned. As with the Cone Spiral bolt, the Fastorq bolt also compresses the resin column as the hex nut pushes down on the resin anchor. Both the Cone Spiral bolt and the Fastorq bolt have seen limited underground use to date, due primarily to economic considerations.

MECHANICALLY-ANCHORED RESIN-ASSISTED TENSIONED BOLTS

With the development of the Shell-Loc system, which utilizes a short resin cartridge to grout a mechanical anchor into the borehole, the combined use of mechanical anchors and resin have enhanced the anchorage capacity and bleed-off characteristics of tensioned bolt installations. This class of roof support has risen in popularity over the years since the inception of the Shell-Loc bolts. Mechanically-anchored, resin-assisted tensioned bolts require no deviations from normal mechanical bolt installation procedures. The mechanical anchor provides initial anchorage to tension the bolt quickly while the resin cures. The new, specially formulated resins require less mixing and ensure a good resin anchor with each installation. These types of systems also have the most varied designs, both in concept and appearance. The latest designs of mechanically-anchored, resin-assisted tensioned bolts can be classified into two types. The first type (Fig. 4) relies on the resin to function as a passive anchor as in normal grouted systems, with the mechanical anchor used to tension the bolt before the resin cures completely. The second type (Fig. 5) causes the resin anchor to become compressed when loaded, similarly to the resin-anchored tensioned bolts discussed previously.

Recently there have been three new designs in the first classification: the S-Bolt, Spiral bolt and Dyna-Roc Plus anchor. With the S-Bolt, the rebar normally used with this type of bolt is replaced with a mechanical bolt that is formed into an "S" shape below the expansion anchor. This configuration aids in the mixing of the resin, and instead of a mechanical delay mechanism, this bolt has extra threads to provide additional time to mix the resin before the expansion anchor is set.

The Spiral bolt consists of a mechanical bolt that has a reverse wound spiral wire mixer crimped onto the threads below the expansion anchor. Because the spiral wire mixes the resin much faster than a rebar, no delay mechanism is required for the expansion anchor. As with the Cone Spiral bolt, the reverse coiled wire tends to push the resin towards the top of the hole during mixing. Spiral bolts have been in use for several years.

The Dyna-Rok Plus anchor functions similarly to the previous bolts; however, tension is achieved in a unique manner. Instead of using an expansion anchor to tension this system, a coarse thread at the end of the bolt is rotated into a split plastic tube. As the bolt goes through the tube, the tube expands in the borehole. This expansion exerts a force against the borehole wall which prevents the tube from slipping in the hole as the bolt is tensioned. The amount of anchorage achieved is controlled by the length of the plastic tube. A resin cartridge is inserted below the plastic and is mixed by the coarse threads of the bolt during insertion and tensioning. This system requires a high torque (300+ft.-lbs.) thread the plastic tube and to tension. Changes in borehole size will affect the installation. Oversize holes will reduce the anchorage capacity and undersize holes will increase the installation torque requirement. The Dyna-Rok Plus anchor is currently undergoing a large-scale test

a West Virginia mine.

Currently there are three designs of roof support that fall under the second type of mechanically anchored, resin-assisted tensioned bolts: the Versatile bolt, Hytec, and the Wedge/Compression bolt.

The Versatile bolt is similar to the Spiral bolt except that, above the anchor a tapered hex nut is locked onto the top of the bolt threads which prevents the nut from turning on the threads as the bolt is tensioned. After the resin cures, additional loads on the bolt cause the nut to push on the resin column and compress it. The Versatile bolt is designed for use in 1-inch and 1 3/8-inch holes. This bolt is relatively new and has seen limited use to date.

The Hytec bolt consists of a mechanical bolt with a 1 1/8-inch-diameter thin wall tube crimped onto the bolt threads below a standard expansion anchor. During tensioning, the tube compresses the resin as it cures. Because the resin is under pressure, it more readily conforms to the hole,which improves the anchorage. Hytec bolts have been available for several years and have been used extensively.

The Compression bolt consists of a headed J-bar and a bail anchor with a wood shear pin in the plug to prevent thread take-up during the mixing of the resin. A small washer is held in place below the expansion anchor by a wire crimped onto the J-bar. The washer compresses the resin during tensioning as the resin cures, resulting in enhanced anchorage and bleed-off characteristics. This system is very recent and has seen limited underground use to date.

FRICTION-REDUCING WASHERS

Recent changes in regulations have affected the applications of some roof support systems. Coal mine operations are now permitted to install tensioned supports up to the yield loads of the bolts. This now gives the mine operators the ability to fine-tune a support to the roof conditions. By varying the installed loads, the stiffness of the support can be adjusted as needed. While this new regulation has permitted a greater latitude to the coal operators in the use of tensioned supports, it has also created a design problem for the bolt manufacturers due to the very high torque (350+ft.-lbs.)requirements necessary to install the larger diameter supports at the yield loads (25,000 - 46,000 lbs.). Several manufacturers have resolved this problem by developing friction-reducing washers (Fig. 6) to replace the standard hardened washer. These washers reduce the friction at the bolt head-plate contact area,which in turn supplies more of the applied torque directly to the bolt, thus achieving higher tension levels.

The Torqrite washer is a standard hardened washer which is coated with a graphite emulsion. Tension/torque ratios in excess of 65:1 have been attained. The Fastorq washer consists of two plated washers sandwiched between a layer of hot-melt glue. As the bolt is tensioned, the friction that is developed heats the glue which acts as a lubricant for the two washers and resulting in tension/torque ratios of 100:1. Other washers use plastic disks, plastic coatings, and beeswax lubricants. These friction-reducing washers all improve the tension/torque relationship over hardened washers; however, there is a wide range in performance and price.

PRESSURE GAGE

The combined use of a mechanical anchor and polyester resin has proven to be an effective bolting system,as previously discussed. However, when fast-setting resin is used with a mechanical anchor, making an actual torque check can be difficult. Once the resin begins to gel, the entire

bolting system may become locked. A spring-back condition may exist where the anchor and bolt are held fast by the resin. In this case, torque higher than the actual installed torque can be applied to the bolt head,but,since the top end of the bolt is locked in by the resin, the bolt may twist in torsion and then spring back when the torque wrench is released. A second type of misleading reading may result when the bolt is not held tightly but the resin provides sufficient resistance to alter the assumed torque-tension ratio. In both of these cases, a manual check with a torque wrench will not correspond to the installed bolt tension. As a result, an alternate method for checking installed torque or tension of some mechanically-anchored, resin-assisted bolts is needed.

The new safety standards for roof, face and rib support which went into effect March 28, 1988, address this area: 30 CFR Part 75, Section 75.204(f)(4) states that"In each roof bolting cycle, the actual torque or tension of the first tensioned roof bolt installed with each drill head shall be measured immediately after it is installed. Thereafter, for each drill head used, at least one roof bolt out of every four installed shall be measured for actual torque or tension." This revised standard is performance-oriented and does not require the use of a torque wrench, as in the past, but only requires that the tension or torque be measured. This allows for the introduction of new technology in the area of torque or tension measurements. One new means of measuring installed bolt torque is to monitor the hydraulic pressure in the roof bolting machine rotation (torque) circuit. In theory, the torque output of a roof-bolting machine is proportional to the pressure in the rotation circuit. To check the feasibility of using a pressure gage to monitor installed bolt torque, underground investigations were conducted at various mines. The following summarizes one such investigation, conducted at a southwestern Pennsylvania coal mine.

The first step of the investigation was to have the company install pressure gages on the various bolting machines in use. Since the mine used continuous mining machines with integral bolters, pressure gages were also installed on these machines. In all, four types of machines were evaluated: continuous miner, two types of single-boom center bolters, and a single-boom bolter used during longwall recovery operations. To accurately measure the torque and thrust during the testing, a torque-thrust-rotation sensor (Fig. 7) was used. The sensor mounts directly on the drill head during bolt installation and measures the actual torque output, thrust and RPM,which is digitally displayed on the read-out box. The test procedure was to install bolts with compression pads at various pressure settings while recording the peak pressure (from machine-mounted gage), torque, thrust and installed bolt tension. The bolt was then checked with a torque wrench. The bolts being installed were mechanically-anchored, and resin-assisted. To ensure a reliable manual torque check, the bolts were installed without resin to eliminate the possible problems previously discussed. This test procedure was used to evaluate the four different machine types. The data obtained from one of these tests is listed in Table I. The second column lists the peak pressure, the third and the fourth columns list the torque and thrust obtained from the sensor, the fifth column presents the bolt load taken from a compression pad and, finally, the last column is the torque reading obtained when using a torque wrench. When analyzing the data, it becomes obvious that an increasing pressure results in an increased torque output and increased bolt load (tension). When a linear

regression analysis is performed using pressure and torque output values, a correlation coefficient, r, of 0.98 is obtained. The correlation coefficient indicates the quality of fit achieved by the linear regression. Values of r close to 1.00 indicate a better fit than values close to zero. Therefore, the equation developed through linear regression, T = -7.75 + P (.15), where P is pressure and T is output torque, fairly accurately describes the linear relationship between pressure and torque for this particular bolting machine. Similar results were obtained from analyses of the data generated from tests on the other three machine types. Once an equation is developed for a particular machine, a chart like the one shown in Table II can be generated which can then be used to help establish an installed pressure range to correspond to the approved installed torque range.

One factor which must be considered when setting an installed pressure range is the effect of thrust applied to the roof bolt during installation. A pressure gage will only indicate the available torque at the drill head and not necessarily the installed torque of a roof bolt. Some of the available torque will be lost in overcoming the effect of thrust on the roof bolt during installation. The ideal solution would be to eliminate the thrust completely,but since that is not feasible, the next best situation is to have a consistent thrust application for every installation. When the thrust is consistent, additional torque can be applied to compensate for the torque loss due to thrust. The amount of additional torque needed to overcome thrust will vary since it depends on the amount of thrust applied and the frictional characteristics,or tension-torque ratio,of the particular roof bolt system. Using the torque-pressure chart that we generated, the following example will show how to approximate the additional torque needed to compensate for thrust when using a pressure gage to monitor installed torque. First we assume that the following conditions exist:

1. An installed torque range of 200 to 250 ft.-lbs. is required.

2. The thrust applied during installation will be 1,000 lbs.

3. The tension-to-torque ratio is 50 lbs tension for every ft.-lb. of torque.

The first step is to calculate the torque loss due to thrust during bolt installation. The torque loss equals the thrust divided by the tension-torque ratio, in our example 1,000 lbs. ÷ 50 lbs./ft.-lbs.= 20 f.-lbs. Therefore, the output torque range needed for the correct installed torque range would increase by 20 ft lbs.to 220 - 270 ft.-lbs..Using the chart to obtain the pressures corresponding to this torque range results in a pressure range of 1,500 - 1,850 psi. The pressure range has been rounded off to the nearest 50 psi. This approach can be used to establish an installed pressure range on any roof-bolting machine equipped with a pressure gage. The results obtained from such an analysis should be verified underground, since the application of thrust during bolt tightening may alter the assumed tension-torque ratio.

In addition to the thrust, several other factors can affect the pressure gage method. The first of these, temperature, does not affect the actual pressure-torque ratio but the amount of pressure available. A machine that is cold can develop a higher pressure, up to 200 psi, than can the same machine at operating temperature,due to the higher viscosity of cold hydraulic fluid. Since it only takes a few minutes for a machine to reach its operating temperature, this should not pose a serious problem. The remaining two

factors, component wear and RPM, can affect the pressure-torque ratio. As the hydraulic system components wear the system becomes less efficient, requiring higher pressures for the same torque output. The effect of wear on the system components can be noticed in as little as two weeks under some conditions. To monitor the effect of wear, a periodic check of the pressure-torque ratio should be made. This periodic check can be made in one of three ways. First, a bolt can be installed dry and checked with a torque wrench. Second, a compression pad or load cell can be used to determine the actual installed bolt tension at a given pressure. Finally, some type of in-line torque meter, installed on the drill head, can be used to check the output torque at a given pressure.

Another factor which can affect output torque is the rotational speed (RPM) of the drill head motor during bolt installation. The torque output at a given pressure is dependent on the RPM. Increasing rotational speed, up to the rated RPM, results in an increasing torque output. Above the rated RPM the torque output remains constant. Because of this inherent characteristic of the drill head motor, erratic RPM during bolt installations can alter the torque output. A higher RPM also produces more momentum in the drill head, which can result in increased torque output when compared to a lower RPM.

The effects due to RPM, thrust, and component wear are not unique to the pressure gage method but are present every time a roof bolt is installed. A reliable manual torque check immediately assesses the effects of these factors, since the actual installed bolt torque is measured directly. Using a pressure gage, on the other hand, is an indirect method of checking the installed bolt torque and requires additional precautions in order to monitor and control the effects of RPM, thrust, and component wear.

The pressure gage method is currently being used in several mines and appears to be a viable alternative in those instances when a reliable manual torque check cannot be made. When a pressure gage is used, the following steps should be taken to ensure that the correct installed bolt torque is achieved:

1. A periodic check of the torque-pressure ratio to assess the effects of hydraulic system wear.

2. A consistent roof bolt installation procedure regarding thrust and RPM.

CONCLUSION

Roof control technology has steadily progressed during the past several decades and now encompasses a wide variety of products. The use of the support systems described in this paper has helped to reduce underground coal fatalities due to roof and rib falls to an all-time low of eight in 1988. Through the combined efforts of manufacturers, mine operators, researchers and government agencies, roof control technology will continue to evolve and to have an impact upon safety in our industry.

TABLE I. In-Mine Data

Bolt No.	Gage (PSI)	Sensor Torque (Ft-Lbs)	Sensor Thrust (Lbs)	Bolt Tension (Lbs)	Torque Wrench (Ft-Lbs)
1	1000	133	<1000	5900	115
2	1000	138	1300	7600	175
3	1000	150	1200	7400	160
4	1200	168	1000	8200	210
5	1225	158	1000	6400	155
6	1225	176	<1000	8200	250
7	1325	183	<1000	10000	220
8	1325	193	<1000	8800	255
9	1470	195	<1000	9500	235
10	1470	204	<1000	8800	200
11	1575	229	<1000	11300	300
12	1810	260	<1000	11200	>300

TABLE II. Pressure-Torque Relationship

TORQUE (FT-LBS)	PRESSURE (PSI)	
150	1052	
160	1118	
170	1185	
180	1252	
190	1318	
200	1385	
210	1452	
220	1518	
230	1585	Installed
240	1652	Pressure
250	1718	Range
260	1785	
270	1852	
280	1918	
290	1985	
300	2052	

$T = -7.75 + P(.15)$
$R = .98$

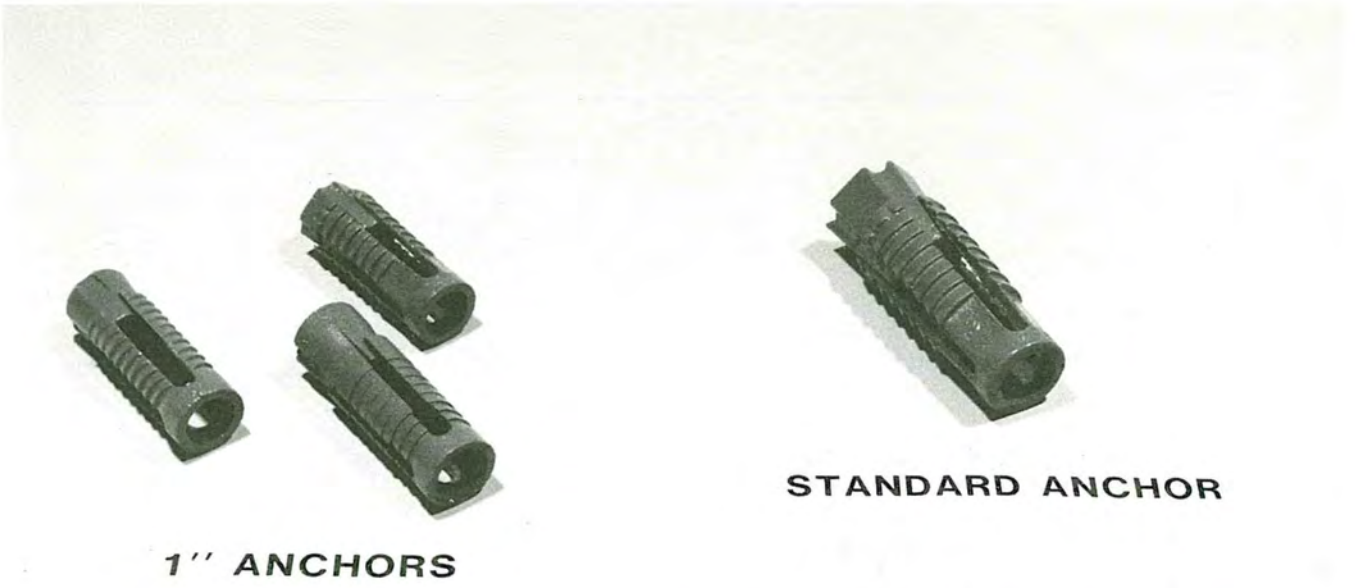


FIGURE 1

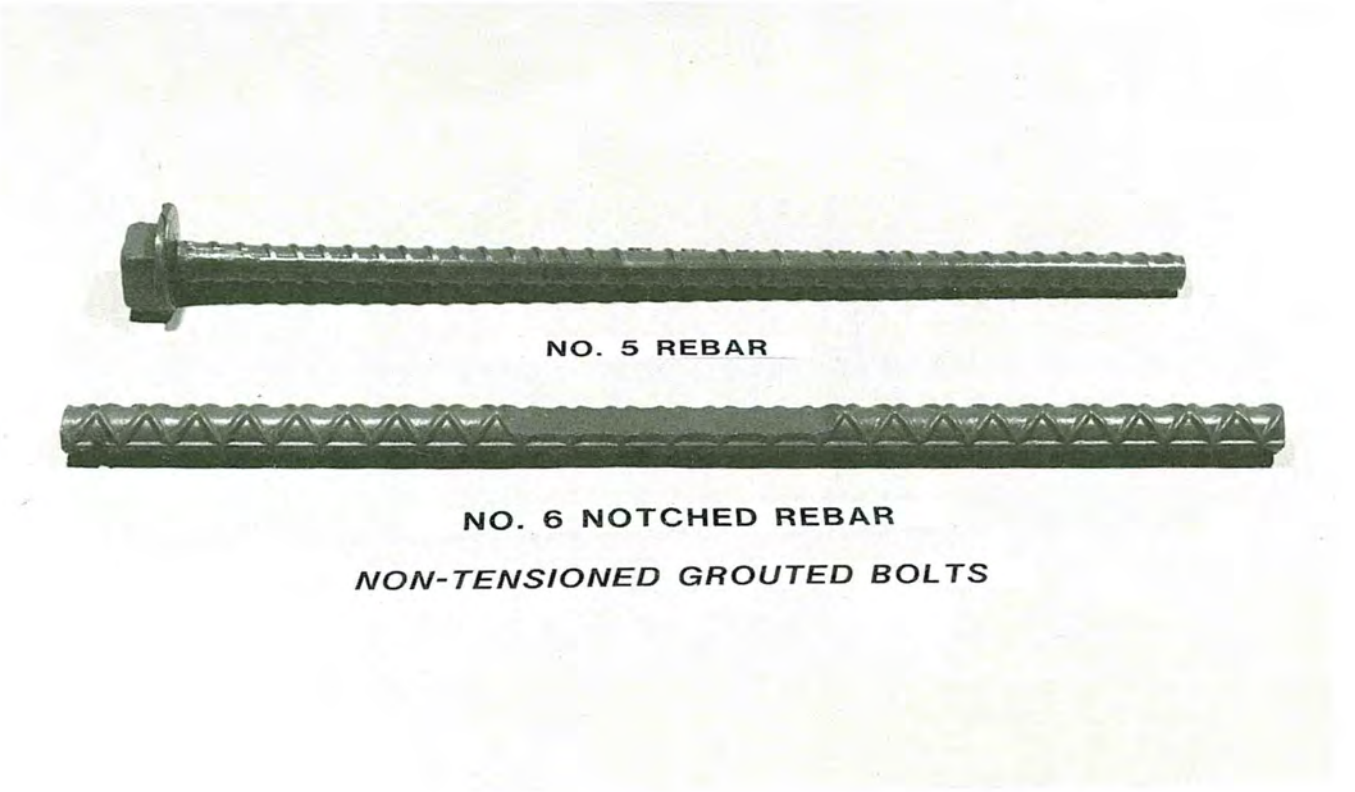
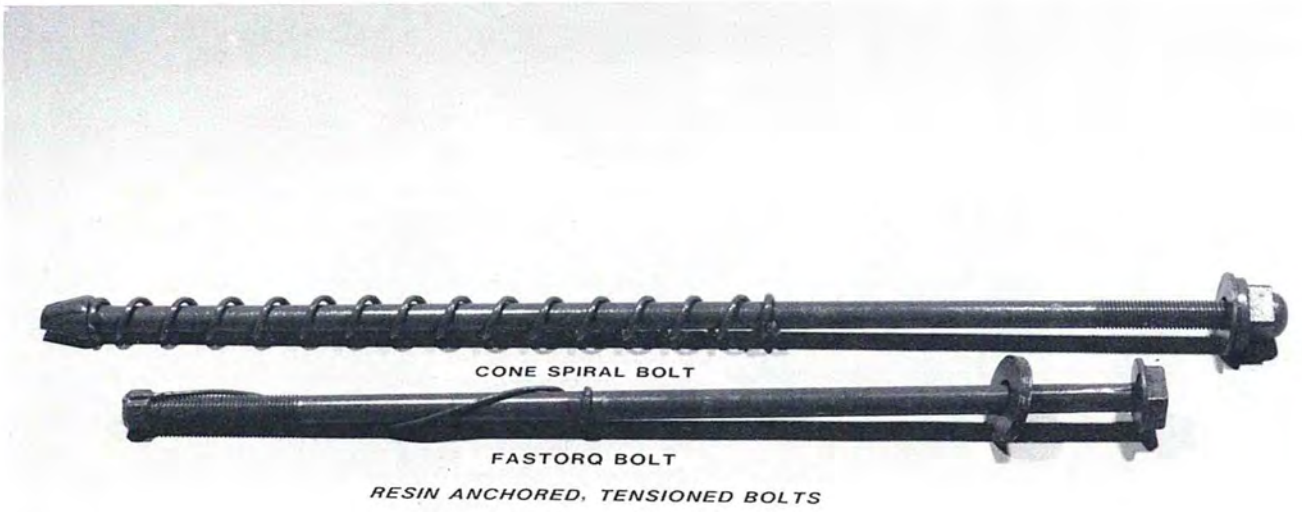
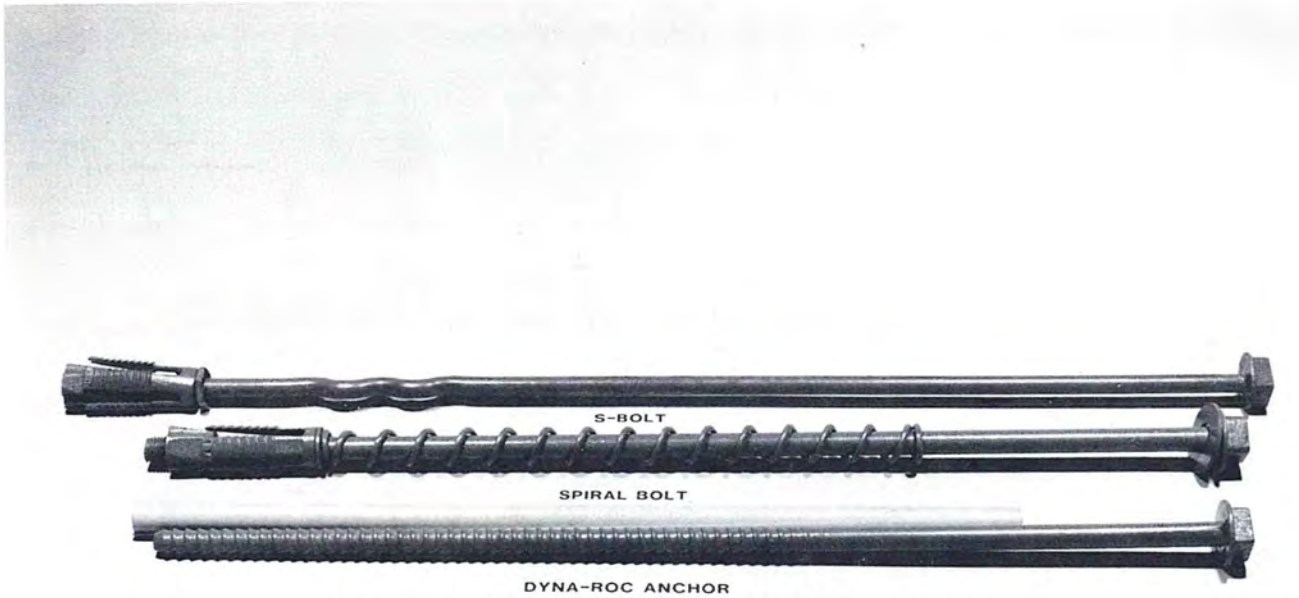


FIGURE 2



RESIN ANCHORED, TENSIONED BOLTS

FIGURE 3



MECHANICALLY ANCHORED, RESIN-ASSISTED TENSIONED BOLTS

FIGURE 4

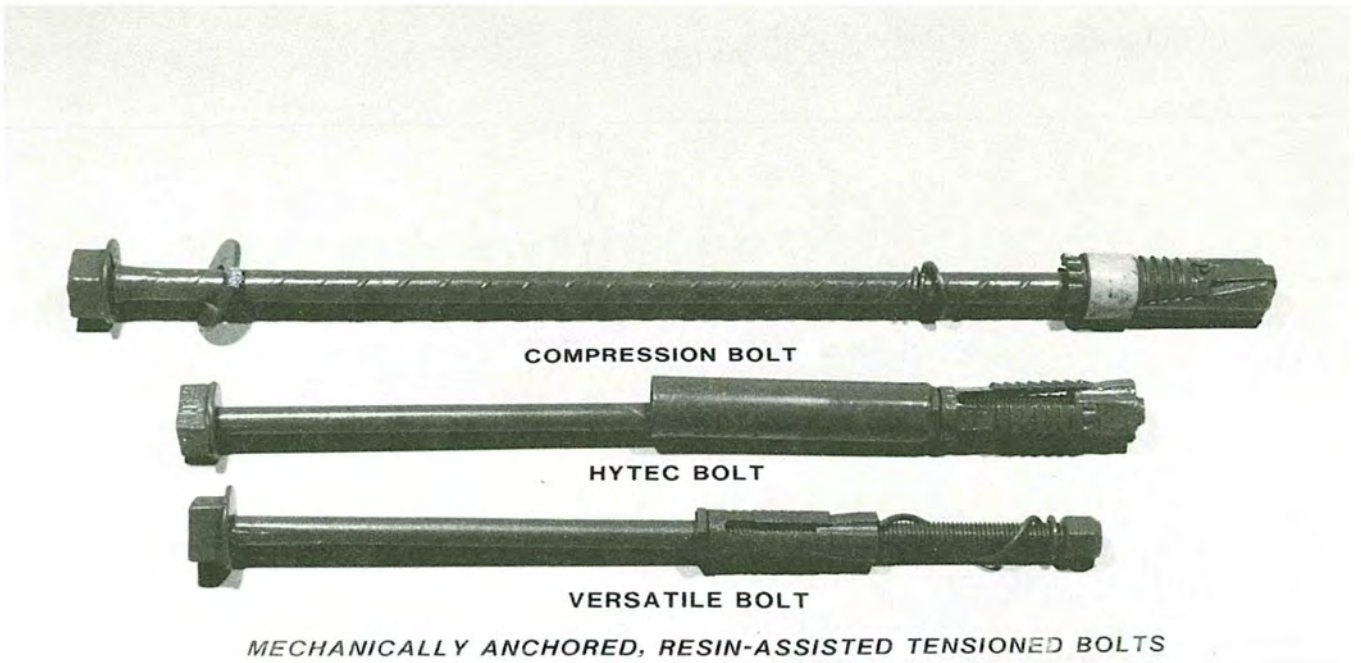


FIGURE 5

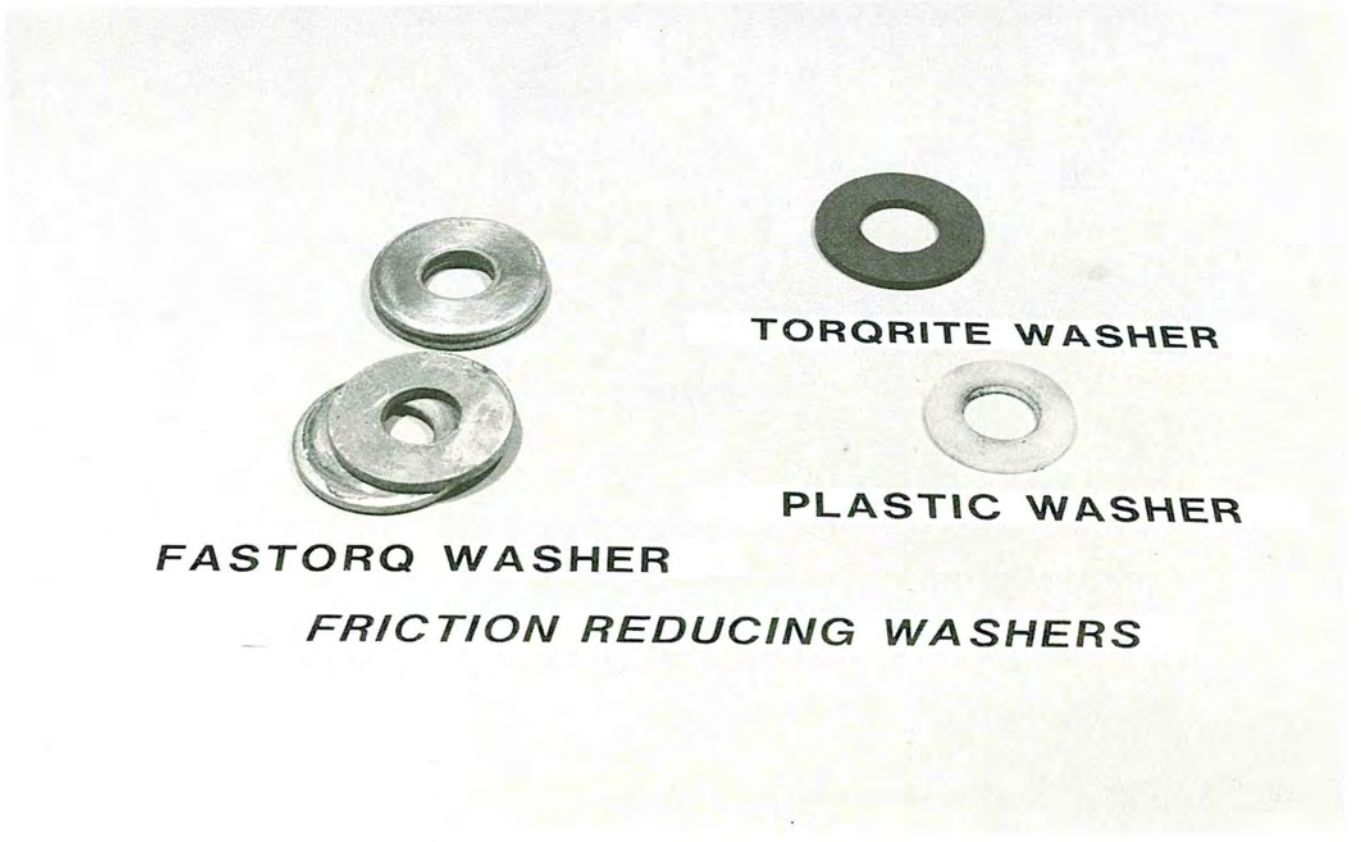


FIGURE 6

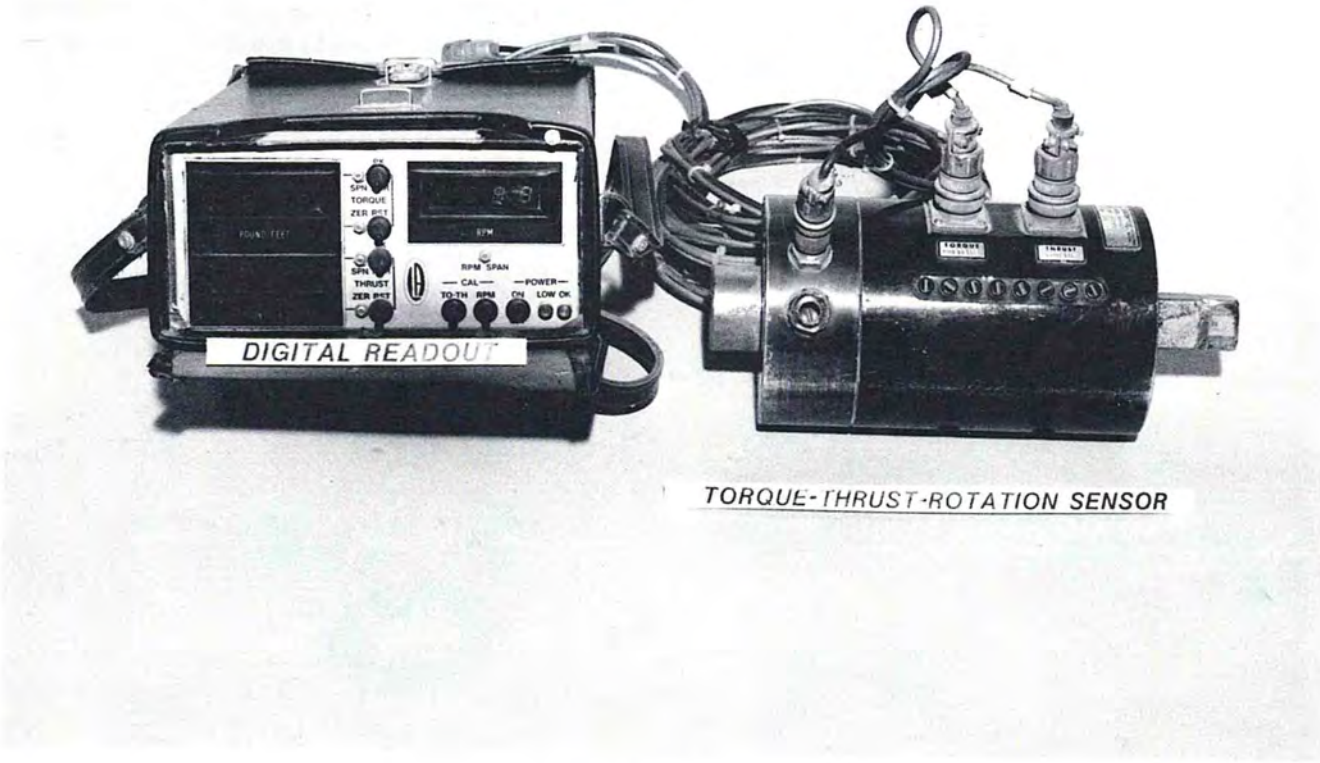


FIGURE 7