FUTURE DIRECTIONS OF MINE HEALTH AND SAFETY IN THE USA

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SUMMARY

This paper summarizes the future directions of mining health and safety research in the United States. It begins by describing the closure of the former U.S. Bureau of Mines (USBM) and the transition of its mining health and safety program into the National Institute for Occupational Safety and Health (NIOSH) and the advantages that this integration provides. Based upon collaboration with other key stakeholders, NIOSH identified the highest mine health and safety research priority needs. The paper defines how the organizational structure at the former USBM Pittsburgh and Spokane Research Centers will be remodelled to better serve these needs. Finally, the future directions of NIOSH mining health and safety research and the strategies for improving the health and reducing the risks of injury and fatality for U.S. mine workers are discussed.

INTRODUCTION

As part of the fiscal year 1996 appropriations process, the U.S. Congress directed that the U.S. Bureau of Mines (USBM) be abolished. Health and safety research at the former USBM research centers at Pittsburgh, Pennsylvania, and Spokane, Washington, was permanently assigned to the National Institute for Occupational Safety and Health (NIOSH) in October 1996. NIOSH is part of the Centers for Disease Control and Prevention within the U.S. Department of Health and Human Services. The Pittsburgh and Spokane Research Centers are among the world's foremost mining research establishments. This merger places federal workplace health and safety research for all American industries under one agency umbrella.

The transition of mining health and safety research from the former USBM into NIOSH creates a novel approach and partnership for improving the health and reducing the risks of injury and fatality for all mine workers. The strengths of NIOSH's public health model, derived from the medical sciences, are greatly enhanced with the integration of the USBM's solutions-oriented engineering expertise. We believe that NIOSH will prove to be a strong organization able to respond to the critical mission of research to improve health and reduce risk in the extractive industries.

IMPORTANCE OF COLLABORATION WITH STAKEHOLDERS

Our research would not be effective without the active participation, cooperation, and support of many individuals, professional organizations, labor, industry groups, and academia. All those involved in the mining industry contribute to our research program in many ways. Mine operators and equipment manufacturers have been major partners in the conduct of this research and have aided in the commercialization of research products. The Mine Safety and Health Administration (MSHA), the federal agency that promulgates and enforces mandatory U.S. mining safety and health standards, has often provided the impetus for research directed toward major health and safety hazards. Additionally, MSHA uses the products and knowledge from our research to improve the health and safety of mining operations. Labor organizations such as The United Mine Workers of America, The United Steel Workers of America, The Operating Engineers and The Teamsters have supported us in our efforts, helping to focus our research from the miners' point of view and have taken the lead in ensuring our research products are implemented to improve safety and health standards. Industry groups, such as the National Mining Association, the National Stone Association, the Bituminous Coal Operators Association and the Northwest Mining Association, which represent large sectors of the mining industry, continue to provide vital input to the research program. These types of interaction are essential for the success of our research program and will continue to play a major role in determining program direction.

IDENTIFICATION OF HIGHEST RESEARCH PRIORITY NEEDS

Despite the progress that has been made in reducing the death and injury toll in mining, it remains one of the most hazardous industries to the American worker. Miners suffer the highest fatality rate of all major U.S. industry divisions (figure 1). From 1981 to 1992, more then 1,500 mine workers lost their lives and more than 210,000 were injured in

the United States. This human suffering is unacceptable and resulted in costs to the nation of over $3.6 billion. Cases of coal worker pneumoconiosis ("black lung") and silicosis are still occurring at an alarming rate. About 10% of underground coal miners are still overexposed based on the 2 mg/m^3 standard mandated by federal law. An analysis by NIOSH suggests that after two decades of regulation there has been little change in the risk of miners of developing noise-induced hearing loss. New or revised (more stringent) standards/regulations are under consideration in the areas of respirable dust, silica dust, and noise. If adopted, their impact should create a heightened urgency to identify and implement appropriate control technology or other intervention strategies to ensure compliance and protection of U.S. miners. Fires and explosions in underground mines are the most feared hazards that mine workers face. From 1978 to 1992, the states of West Virginia, Kentucky, Pennsylvania, Illinois, and Virginia experienced more than 20 mine fires each. Although mine disasters have diminished over the decades, the potential for fires and explosions will exist as long as we mine coal and extract minerals, and new mining methods can create new and possibly deadly routes to disaster. Roof falls and other ground failures continue to be of major concern to the mining community as these types of incidents account for over 40 % of the fatalities in underground mines. For the period of 1990 to 1996, there were 122 roof and rib fall fatalities in underground mines in the U.S.

In November 1996, we held the first round table discussion to solicit input from our key stakeholders with regard to priority health and safety research needs for mining. Based on the ensuing dialogue, our health and safety program will evolve toward the following identified highest priority needs: dust control and measurement, including silica, diesel, and toxic substances; hearing loss prevention; human factors; haulage; equipment design; surface and noncoal mining; new and emerging mining practices and technologies; ground control; fires and explosions; and life support.

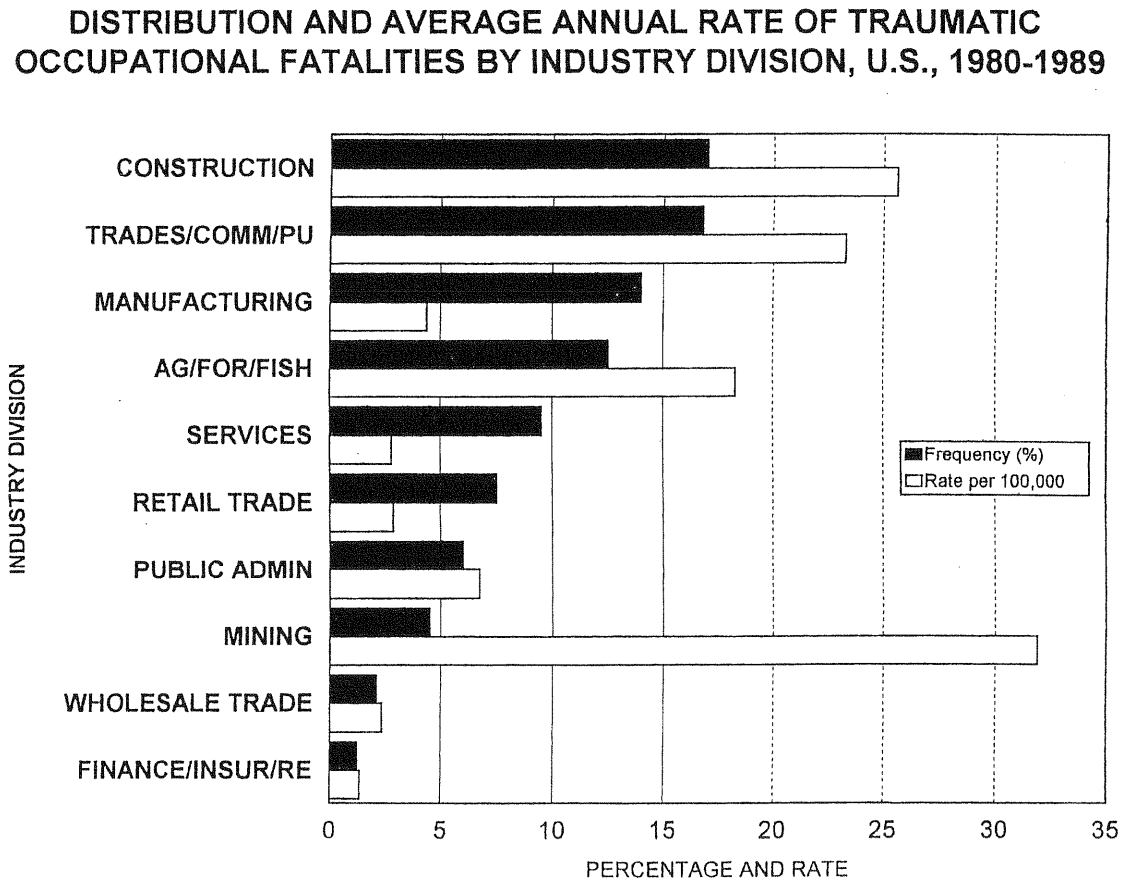

Figure 1 - Distribution and average annual rate of trauma: occupational fatalities by industry division in the United States, 1980-89

NIOSH MINING HEALTH AND SAFETY RESEARCH PROGRAM

Based on an extensive review of the current program, the statistics related to mining safety and health, the above identified priority research areas, and the projected trends within the mining industry, a new organizational structure for mining health and safety research in NIOSH has been identified. The program will be principally implemented at the Pittsburgh and Spokane Research Laboratories (formerly called centers), with support from other NIOSH locations as appropriate. The management approach adopted for the mining health and safety program will include not only the core research programs at Pittsburgh and Spokane Research Laboratories but will incorporate expertise and resources from across the Institute. This approach will provide optimal use of resources within NIOSH to address mining-related issues and needs. The specific organizational structures for Pittsburgh and Spokane are designed to parallel other NIOSH divisions.

Associate Director for Mine Safety and Health Research

NIOSH has created a position of Associate Director for Mine Safety and Health in the headquarters office and has appointed an Acting Associate Director. This position reports directly to the Director of NIOSH. A search committee has been established, and NIOSH is proceeding with a nationwide search for a permanent Associate Director. The position will (1) serve as the focal point for mine safety and health research for NIOSH, (2) plan, direct, and implement a comprehensive program for mining safety and health research, (3) coordinate development, analysis, and dissemination of mining health and hazard surveillance statistics, (4) manage the research activities of the Pittsburgh and Spokane Research Laboratories, (5) stimulate and contribute to the development and recommendation of appropriate criteria for new standards, NIOSH policy, documents, or testimony related to health and safety in mining industries, and (6) serve as the NIOSH focal point for extramural interaction with key mining safety and health stakeholders from industry, labor, and other government agencies.

Pittsburgh Research Laboratory

The function of the Pittsburgh Research Laboratory (PRL) will be to (1) provide leadership for prevention of work-related illness, injury, and fatalities of miners, (2) carry out the surveillance of fatal and nonfatal traumatic injuries, occupational diseases, health and safety hazards, and the use of control technology and protective equipment for prevention of injury and disease in mining, (3) conduct research on the measurement, monitoring, and control of dust and other toxic substances to which miners may be exposed, (4) conduct laboratory and field research to evaluate and control hearing loss and occupational noise exposure in mining, (5) conduct field investigations and laboratory studies on mining injuries and the means for their prevention, (6) conduct laboratory and field investigations to better understand the causes of catastrophic events that may lead to fatalities, such as fires, explosions, and structural or ground failures, (7) develop sensors, predictive models, and engineering controls to reduce miners risk for injury or death, (8) translate research findings, new control technology concepts, and newly identified approaches to health and safety problems affecting miners into usable effective interventions, and (9) utilize the unique facilities and resources of the laboratory as a national resource in collaboration with other NIOSH units, as well as other departments and agencies of the government.
PRL will consist of four research branches and two cross-cutting activity groups, the functions of which are described below.

Dust and Toxic Substance Control Branch

The function of the Dust and Toxic Substance Control Branch at PRL will be to (1) develop, plan, and implement a program of research to develop or improve personal and area direct reading instruments for measuring mining contaminants including, but not limited to, respirable dust, silica, and other toxic substances and mixtures, (2) conduct field tests, experiments, and demonstrations of new technology for monitoring and assessing mine air quality, (3) design, plan, and implement laboratory and field research to develop airborne hazard reduction control technologies, (4) carry out field surveys in mines to identify work organization strategies that could result in reduced dust or toxic substance exposure, (5) evaluate the performance, economics, and technical feasibility of engineering control strategies, novel approaches, and the application of new or emerging technologies for underground and surface mine dust and toxic substance control systems, and (6) develop and evaluate implementation strategies for using newly developed monitors and control technology for exposure reduction or prevention.

Hearing Loss Prevention Branch

The Hearing Loss Prevention Branch will (1) plan and conduct laboratory and field research on noise-

induced hearing loss in miners, (2) conduct field dosimetric and audiometric surveys to assess the extent and severity of the problem and to identify those mining segments in greatest need of attention and to objectively track progress in meeting loss prevention goals, (3) conduct field and laboratory research to identify noise generation sources and to identify those areas most amenable to intervention activities, (4) develop, test, and demonstrate new control technologies for noise reduction, (5) evaluate technical and economic feasibility of controls, and (6) develop, evaluate, and recommend implementation strategies to promote the adoption and use of noise reduction technology.

Mining Injury Prevention Branch

The Mining Injury Prevention Branch will (1) conduct laboratory, field, and computer modeling research to focus on human physiological capabilities and limitations and their interactions with mining jobs, tasks, equipment, and the mine work environment, (2) assess the health and safety relevance of mining equipment design features using scientific and engineering techniques, and analyses of reported case-studies of mining incidents that lead to traumatic injuries or fatalities, (3) design and conduct epidemiological research studies to identify and classify risk factors that are causing or may be causing traumatic injuries to miners, (4) design, build, and test proposed interventions, including demonstrations of proposed technologies using laboratory mockups, full-scale demonstrations at the laboratory's experimental mines, or through field evaluation in operating mines, and (5) evaluate and recommend implementation strategies for injury prevention and control technologies developed by the laboratory.

Disaster Prevention and Response Branch

The Disaster Prevention and Response Branch will (1) conduct laboratory and field investigations of catastrophic events such as fires, explosions and catastrophic structural or ground failures to better understand cause-effect relationships that trigger or propagate such events, (2) through better understanding of these mechanisms, design and implement appropriate interventions, (3) develop, test, and promote the use of disaster prediction and risk evaluation systems for control or reduction of risk, (4) develop criteria and tests for explosives to determine their suitability for mine use and transportation, (5) evaluate and recommend implementation strategies for disaster prevention, and (6) assist in the development and evaluation of curricula for mine rescue, fire-fighting, and the use of life support (self-rescuer) equipment, in conjunction with other NIOSH health education, health communication, and education and information activities.

Surveillance, Statistics, and Research Support Activity

The Surveillance, Statistics, and Research Support Activity is a new program at PRL that will (1) collect and analyze health and safety data related to mining occupations in order to report on the overall incidence, prevalence and significance of occupational safety and health problems in mining, (2) describe trends in incidence of mining-related fatalities, morbidity, and traumatic injury, (3) conduct surveillance on the use of new technology, the use of engineering controls, and the use of protective equipment in the mining sector, (4) coordinate surveillance activities with other NIOSH surveillance initiatives, (5) provide statistical and computer support for PRL surveillance and research activities, (6) analyze and assist in the development of research protocols for developing studies, and (7) conduct mining-relevant risk analyses and assist with interpretations for development of NIOSH policy or documents.

Extramural Coordination and Information Dissemination Activity

The Extramural Coordination and Information Dissemination Activity at PRL will (1) collaborate with research staff to translate findings from Laboratory research to produce compelling products that motivate the mining sector to engage in improved injury control and disease prevention activities, (2) incorporate recommended control technologies, work practices, and findings of technological feasibility into NIOSH policy documents and testimony, (3) coordinate with other health communication, health education, and information dissemination activities within NIOSH to ensure that mining research information is effectively integrated in the NIOSH dissemination and intervention strategies, (4) serve as the laboratory focal point for partnerships with labor, industry, and academia and other government agencies to foster mission-relevant responsive research, (5) assist in the development of mission-relevant Cooperative Research and Development Agreements (CRADA's) and patents, (6) coordinate mission-relevant technical assistance and response activities, and (7) coordinate mining grants and cooperative agreements with the NIOSH Office of Extramural Coordination and Special Projects.

Spokane Research Laboratory

The function of the Spokane Research Laboratory (SRL) will be to (1) provide leadership for prevention of work-related illness, injury, and death in the extractive industries in the Western United States, (2) conduct surveillance and track trends of fatal and nonfatal traumatic injuries, occupational diseases, health and safety hazards, and the use of control technology in the extractive industries, with a focus on unique Western issues such as those associated with deep metal mines, Western coal mines, and precious metal deposits, (3) conduct field investigations, health hazard evaluations, and laboratory studies of occupational diseases, injuries, and fatalities with focus on western-area mineral-extractive industries, (4) conduct laboratory and field investigations to better understand the causes of catastrophic events that may lead to multiple injuries and fatalities, such as collapse of underground workings, massive slope failures, and the collapse of mining facilities, (5) develop, test, and demonstrate sensors, predictive models, and engineering control technologies to reduce miners risk for injury or death, and (6) develop and recommend appropriate criteria for new standards, NIOSH policy, documents, or testimony related to health and safety in the extractive industries.
SRL will consist of two research branches and two cross-cutting activity groups, the functions of which are described below.

Mining Injury and Disease Prevention Branch

The function of the Mining Injury and Disease Prevention Branch at SRL will be to (1) design and conduct field and laboratory research studies to identify and classify risk factors that are causing or may be causing traumatic injuries or illness to miners, (2) design, build, and test proposed interventions to reduce risk of injury or disease, including demonstrations of proposed control technologies, (3) assess the health and safety implications of mining equipment design features using scientific and engineering techniques, and (4) evaluate and recommend implementation strategies for injury and disease prevention and the effective utilization of control technologies developed by the laboratory.

Catastrophic Failure Detection and Prevention Branch

The Catastrophic Failure Detection and Prevention Branch will (1) conduct laboratory and field investigations of catastrophic events such as collapse of underground workings, massive slope failures, collapse of mine facilities, or other events that lead to traumatic injuries or fatalities, (2) develop computer visualization models to simulate mine conditions and test alternative mining methods and approaches for risk reduction and catastrophic failure prevention, (3) develop, test, and promote the use of catastrophic failure prediction and risk evaluation systems, and (4) evaluate and recommend implementation strategies for catastrophic failure prevention.

Mining Surveillance and Statistics Support Activity

The function of the Mining Surveillance and Statistics Activity at SRL will be to (1) describe trends in incidence of mining-related fatalities, morbidity, and traumatic injury, (2) conduct surveillance on the use of new technology and the use of engineering controls, (3) coordinate the surveillance activities with other Institute-wide surveillance initiatives, (4) provide statistical support for all SRL surveillance and research activities, (5) assist in the development of research protocols, and (6) communicate the results of surveillance activities to researchers to assist in the planning and prioritization of future studies.

Extramural Coordination and Information Dissemination Activity

The Extramural Coordination and Information Dissemination Activity at SRL will (1) coordinate with other education and information dissemination activities within NIOSH to ensure that coordinated and comprehensive mining research information is effectively integrated into the NIOSH dissemination and intervention strategies, (2) serve as the laboratory focal point for partnerships with labor, industry and academia involved with Western extractive industries, (3) assist in the development of mission-relevant CRADA's and patents, and (4) coordinate mission-relevant technical assistance and response activities for the Western United States.

NATIONAL OCCUPATIONAL RESEARCH AGENDA

NIOSH and its partners in the public and private sectors developed the National Occupational Research Agenda (NORA) to provide a framework to guide occupational safety and health research into the next decade—not only for NIOSH, but also for the entire U.S. occupational safety and health community. Approximately 500 organizations and individuals outside of NIOSH provided input into the development of the agenda. This first-ever attempt to guide and coordinate research nationally responds to a broadly perceived need to systematically address those topics that are most

pressing and most likely to benefit American workers and the nation. The agenda identified 21 research priorities, which are grouped into three categories. Our Mining Health and Safety Research Program has been fully coordinated with the NORA plans and recommendations, with 13 of the 21 priority areas for research identified by NORA directly applicable to our program, as follows:

NORA Category	Priority Research Area
Disease and Injury	Allergic and Irritant Dermatitis Asthma and Chronic Obstructive Pulmonary Disease Hearing Loss Low-Back Disorders Musculoskeletal Disorders of the Upper Extremities Traumatic Injuries
Work Environment and Work Force	Emerging Technologies Organisation of Work
Research Tools and Approaches	Control Technology and Personal Protective Equipment Exposure Assessment Methods Risk Assessment Methods Surveillance Research Methods

FUTURE MINING HEALTH AND SAFETY RESEARCH

Based on the surveillance work to date and customer/partner/stakeholder input, it is clear that there is a need for an expansion of efforts in a number of areas. The level of effort in health and safety surveillance activities will be increased to provide a clear determination of the experience of different sectors of the U.S. mining industry. These surveillance and statistical studies will assist in formulating research program redirection and new project starts. In line with the need for increased surveillance activity, our Accident Cost Indicator Model (ACIM) will be redesigned so that it can generate reliable, estimated costs for U.S. mining accidents, injuries, and illnesses. It is also proposed to extend the capabilities of the model to cover sectors of the industry that were not covered by the original model. We will also collect and disseminate data on the characteristics of the mining work force as a resource for identifying populations at risk of occupational injuries and illnesses. The inherent health and safety risks and the potential for risk reduction associated with various coal mining machinery control scenarios will be analyzed, such as manual operation from within the cab, remote off-board pendent operation, remote teleoperation and remote computer-assisted operation.

Our future research program will see an increased emphasis on developing technology for the measurement of respirable dust and on dust control for both surface and underground mining operations. Longwall productivity has radically increased over the past decade in the United States. This increase, however, has meant that far more dust is being generated (figure 2). We will investigate new technologies for dust measurement based on tapered element oscillating microbalance (TEOM®) and differential pressure on collection filters. We will be field testing a machine-mounted continuous respirable dust monitor in a number of underground coal mines for application of this new measurement approach to potentially improve dust control systems. Additionally, we will investigate the current technology and the application of innovative concepts for controlling respirable silica dust in underground mine environments. More than 40% of the continuous miner operators and helpers and more than 50% of the roof bolter operators exceed the 5% silica limit. The high incidence of silica overexposure suggests that current technologies do not consistently limit respirable silica dust exposures. Therefore, silica exposures will be categorized according to mining parameters, control methods, equipment, and mining method. Recent preliminary examination of surface miners has shown that the incidence of lung abnormalities is not concentrated among the drillers, but rather is distributed among numerous occupations. We will focus on eradicating silicosis in all surface operations through evaluation of multioccupational dust sources and current control technologies, sample variability, drilling parameters, and testing of new control technology.

It is also clear that there is a need for an expansion of effort in the area of hearing loss prevention, including improved noise control methods applicable to mining. Excessive noise exposure is a persistent and growing problem. A recent analysis by NIOSH of two large audiological databases suggests that there has been little change in the risk of miners developing a hearing loss, with as many as 90% of 50-year-old miners suffering significant hearing loss (figure 3). We will initiate an enhanced program on hearing loss prevention and begin to lay the groundwork for rapid growth within the next few years. This will begin with a comprehensive study combining the efforts of past research studies incorporating worker noise exposure studies and equipment noise data. The resultant database will be an up-to-date comprehensive profile of the mining population as a function of the worker's job function and environment. The study will encompass all aspects of mining, including surface and underground coal and metal/nonmetal mining. The hearing loss program will be initialized with the following focus: 1) a national workshop with partners will be conducted to help define technology, research,

equipment design and training needs, 2) a cross-sectional survey of mines will be conducted to assess the greatest problem areas, 3) a demonstration project will be performed to show the positive effects of technology intervention to reduce noise levels, 4) improve the existing noise research infrastructure at Pittsburgh Research Laboratory by expanding lab capabilities and increasing noise control personnel and expertise, 5) implement quiet-by-design technology by cooperative research with equipment manufacturers in order to produce a new generation of drills, cutting heads and conveyors, 6) technical assistance by jointly working with industry on common problems then reducing the lessons learned to practice and aggressively conducting technology transfer throughout the industry.

Our program will see an increased emphasis on preventing injuries from materials handling activities, which is one of the most hazardous tasks in underground mining operations. The number of injuries may be reduced by the correct selection, transportation, loading, warehousing, and construction of ground support structures.

Alternative supports are being developed that promise to reduce the injury rate due to the bulk handling of ground support structural material. It is essential to determine the yield and strength limits of these supports to safely utilize them. Through a program of job risk assessment, field performance surveillance, and laboratory testing, data can de developed to produce guidelines on the safe selection and construction of ground support in underground coal mines. Additionally, we will study the applicability and methodology for introducing effective loss prevention techniques into the mining industry. Strategies and best practices models, used successfully in other industries, such as construction, will be identified and adapted for addressing specific mining safety problems in all segments of the industry. We will also examine current state-of-the-art sensor and computer technology for implementation of proximity detection and collision avoidance systems in mining applications to improve mine worker safety.

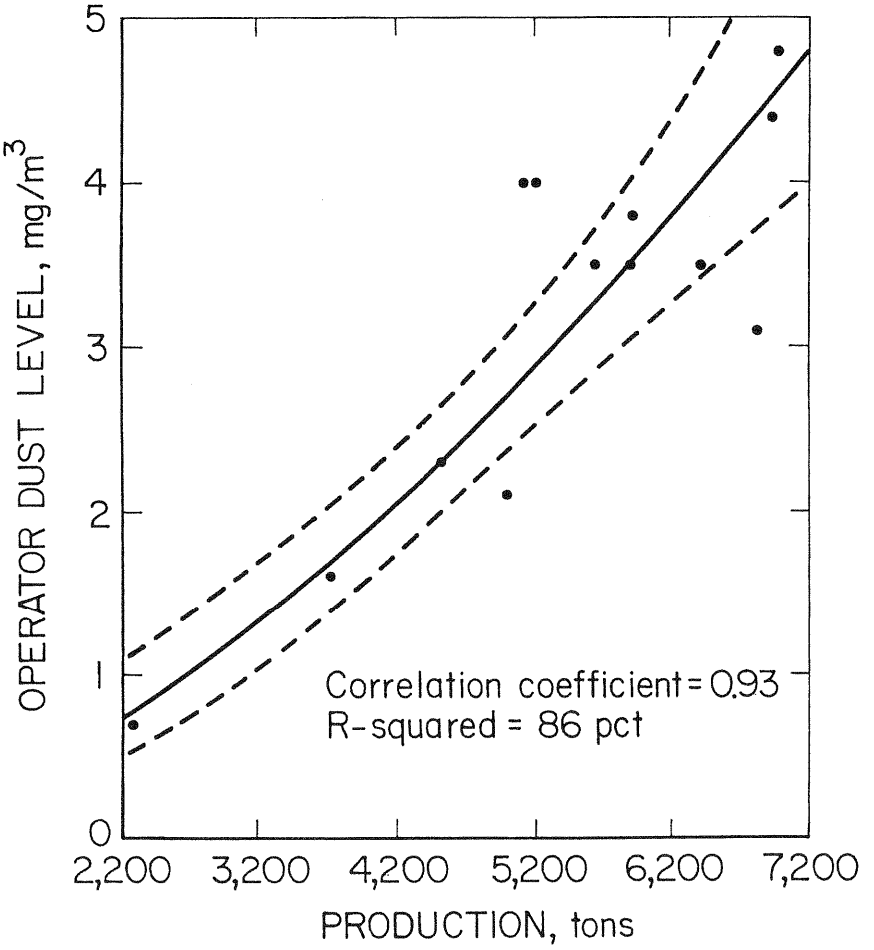

Figure 2 - This graph illustrates that as longwall productivity increases, more dust is generated.

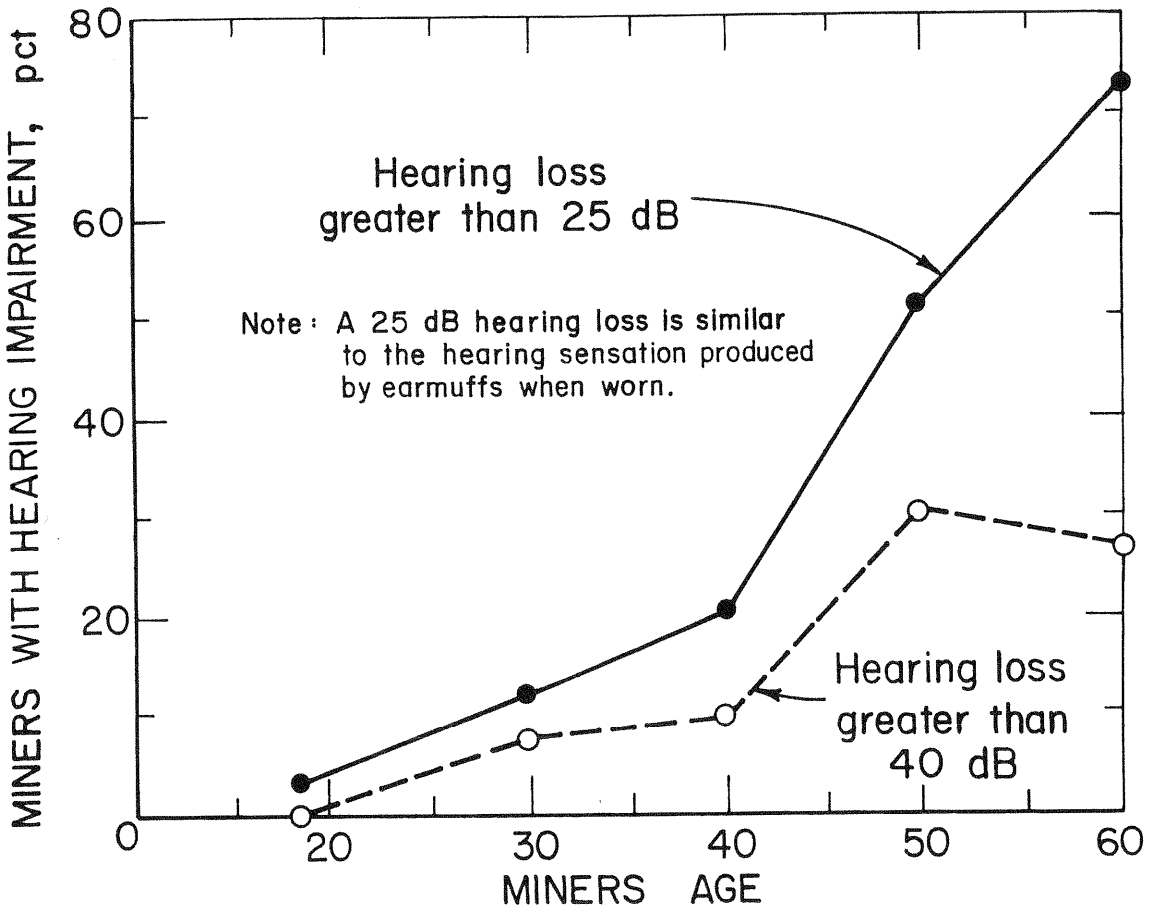

Figure 3.—Hearing loss of coal miners as a function of age.

We will continue to conduct high-priority research in preventing injuries and fatalities from ground instabilities, as well as from fires and explosions, and will continue research on life support needs for surviving mine fires and explosions. Of the 2,625 U.S. roof and rib failure incidents reported to MSHA in 1996, 1,279 were in intersections. Through the careful analysis of existing roof falls, geology, and support, coupled with focused field instrumentation of ground movement in test intersections, we will develop a model that will describe the expected stability of intersections. Armed with this information, the mine engineer can proceed with the safe design and support of intersections. Three fatalities in 1996 attributable to bumps (violent failures of overly stressed coal) vividly reminded the mining industry that the bump problem has not been eliminated in the United States. The basic research approach will be to instrument an appropriate field site in the Western United States and determine the main mine roof and gob behaviour. The field instrumentation work will be supported by analytical and numerical models appropriate for characterizing and simulating the observed behaviour. The outcome will be improved engineering concepts and designs that implement the new understanding of overburden behaviour for reducing bump incidences.

We will maintain our core competencies in fires, explosions and explosives research to ensure that emerging technologies and changing conditions within the mining industry do not adversely impact the safety of American miners. Even with the many advances and achievements for preventing mine disasters, there are about 100 mining-related ignitions per year in the U.S. and, on average, one major underground mine fire or explosion annually. Our research program will continue to study the factors associated with these incidents and will focus on the development of technologies and systems for preventing or minimizing their impact on mine workers.

Our research program will include an expanding emphasis on addressing the health and safety problems of surface and noncoal mining operations. Safety hazards associated with the use of large equipment at surface mines will be studied and technologies and systems for controlling the hazards will be developed. Noncoal mining operations, including metal mines, nonmetal mines and underground stone mines will also receive increased emphasis in our future research program. Our program will focus on eliminating or reducing the hazards associated with equipment operation, roof falls and other ground failures, and materials handling.

CONCLUSION

The transition of the health and safety research program from the former USBM to NIOSH has proceeded in a orderly fashion with support from our major stakeholders. The availability of the combined resources of NIOSH enhances the opportunity to address issues and needs in a timely manner. Further, the capabilities that the USBM health and safety research program brings to NIOSH will enhance the overall NIOSH capabilities for all aspects of workplace health and safety.

The coordination with external interests and partners will continue to be a priority of NIOSH. Based on a review of the surveillance data and input from constituents, our program will be redirected to more equitably address health and safety issues in surface mines, as well as noncoal mining operations. Emerging practices and technologies will be in the front of our vision; it is best to address issues and needs before they become large-scale workplace health and safety problems. The ability to avoid problems versus correcting them afterward is of primary interest to NIOSH.

Input and identification of needs from customers will ensure a program based on sound science and one that is fully responsive to the mandate of our program. The NIOSH health and safety staff at Pittsburgh and Spokane will continue to work together with our partners to resolve the key issues of safety and health that American miners face today and will face into the 21st century.

ACKNOWLEDGMENTS

I would like to acknowledge the many contributions of the employees at Pittsburgh and Spokane Research Laboratories and for their fine efforts in assisting with the preparation of the research program that is discussed in this report. I would also like to recognize the management teams at Pittsburgh and Spokane for helping define the future research program and for assisting in the writing the report.