Proceedings

THIRTY-THIRD ANNUAL INSTITUTE ON MINING HEALTH, SAFETY AND RESEARCH 2002

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PROCEEDINGS
THIRTY-THIRD ANNUAL INSTITUTE ON MINING HEALTH, SAFETY AND RESEARCH

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The Institute would also like to express its appreciation to Ray McKinney and John Urosek for making a last-minute change to the program venue in order to provide participants with an up-to-date and informative overview of the Quecreek Rescue Operation.

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INTRODUCTION

The *Proceedings* contain the presentations made at the Thirty-Third Annual Institute on Mining Health, Safety and Research, held at the Hotel Roanoke and Conference Center in Roanoke, Virginia from August 27th through August 30th, 2002.

The first twenty-seven Annual Institutes were held at Virginia Tech in Blacksburg, Virginia. The Twenty-Eighth Annual Institute was held in Salt Lake City and co-hosted by the University of Utah and Virginia Tech. Subsequently, the venue has alternated between the east and west, with the two Universities working together as co-hosts. The Institute enjoys wide support from the mining community and was co-sponsored by the following organizations:

- Department of Mining and Minerals Engineering, Virginia Tech
- Department of Mining Engineering, University of Utah
- Mine Safety and Health Administration (MSHA), U.S. Department of Labor
- National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention
- National Mining Association
- National Stone, Sand and Gravel Association
- Virginia Aggregates Association
- Bituminous Coal Operator's Association
- Society of Mining, Metallurgy, and Exploration

The Institute provides an information forum for mine operators, managers, superintendents, safety directors, engineers, inspectors, researchers, teachers, state agency officials, and others with a responsible interest in the important field of mining health and safety. In particular, the Institute is designed to help mine operating personnel gain a broader knowledge and understanding of the various aspects of mining health and safety and to present them with methods of control and solutions developed through research.

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KEYNOTE SESSION:

HEALTH AND SAFETY'S ROLE IN A CHANGING INDUSTRY AND CHANGING WORLD

Session Chair

Tom Novak
Professor and Head
Department of Mining and Minerals Engineering
Virginia Tech

KEYNOTE SPEECH: REMARKS BY DAVE D. LAURISKI

Assistant Secretary of Labor for Mine Safety and Health

INTRODUCTION

It's a great pleasure to be here. The Annual Institute on Mining Health, Safety and Research has become a grand tradition. It's always a pleasure to meet on this occasion, renew our good working relationships, and exchange the latest information for improving health and safety in the Nation's mines.

I want to start by taking a few minutes speak about the Quecreek rescue. Ray McKinney and John Urosek, who both were on the scene, are going to address the technical side of the rescue this afternoon, but I would also like to give my perspective.

On July 28, as you know, we rescued nine miners from the Quecreek Mine in Western Pennsylvania. I was onsite along with Ray and John and approximately 50 others from MSHA who played critical roles in the rescue. This was a monumental event, a monumental experience, and -- perhaps some others are here today who took part in the rescue, from MSHA or other organizations?

As all of us worked through the days and nights to get to the miners, we knew the eyes of the nation were on Quecreek, because at one point someone counted 38 satellite dishes. But we were surprised afterwards to learn that it was not only a national event -- it was a world event, watched around the clock on satellite TV, as far away as China.

If you saw the news media coverage, you probably noticed that during the emergency the media emphasized a few individuals. Since I was there, I can tell you that this was largely a result of who was free to speak to the cameras at a given time, and gave an artificial idea of what it was actually like.

The fact is, the Quecreek rescue was a huge team effort. Critical roles were played by MSHA; several Pennsylvania agencies; local mining companies; private firms with technology to offer; individual miners; the U.S. Navy; medical, fire and public safety personnel; humanitarian organizations; clergy – even now, I probably don't know them all, and **each one has a story to tell.**

Among all the others, MSHA was able to make some key contributions. For instance:

- **MSHA provided the mobile command center where Federal, State and company personnel jointly controlled the overall process.** This vehicle is specially equipped for communications in a mine emergency and provided a command center where key officials could meet, review information, discuss, reach decisions and communicate with their own people and with the outside world. Originally we had the command center positioned near the mine portal.
- We later moved the command center to the drill site for closer control.

- **MSHA provided a seismic monitoring system to check for signs of life.** This system has been successfully used in other emergencies including the Mexico City earthquake. In this case, the system did not detect any signs of life due to surface noise from drilling and other activities. However, we never gave up hope, because throughout the whole process, we never had any information that would indicate the miners were **not** alive. The very first borehole drilled into the area where the miners were trapped was a 6-inch borehole intended for communications. As soon as it was down, we heard nine thumps on the drill, and concluded that we had nine miners alive. Thursday morning was our last communication with the miners until the early hours of Sunday, but everyone kept going day and night at full intensity on the assumption that they were alive and waiting for us.

- **MSHA staff came up with the idea to keep pumping compressed air into the pocket where the miners were trapped.** The first 6-inch borehole, originally drilled for communication, turned out to be life saving. The miners were trapped in a confined area higher in elevation than the main part of the mine. All exit routes were filled with water to the roof, water had flooded the mine portal. We had pumps going to lower the water, and kept adding more pumps, but at this point the water was still rising toward the miners. John Urosek saw what had to be done. At his urging, an air compressor was used to pump air at high pressure down the 6-inch borehole. This served three purposes: 1) It provided oxygen to the miners, who were trapped in a confined area where they could have suffocated. 2) It provided warmth in the cold, damp environment where hypothermia was a grave concern. 3) And, the compressed air exerted pressure against the rising water. Essentially, the miners were in a protected space, or as some have put it, a bubble.

- **MSHA determined how much water had to be pumped out before it would be safe to penetrate the mine workings with the large drill being used to develop the rescue shaft.** We had to think ahead about what would happen when the rescue shaft entered the "bubble." If air pressure was all that was holding back the water, then as soon as the rescue shaft went through, air would rush out of the rescue shaft, and the water would rise and fill that protected space. We could lose the miners right there. MSHA's Dr. Kelvin Wu calculated how much water had to be pumped out before we could be **sure** it was safe to put through that rescue shaft. If you watched the news, you probably remember drill problems occurring with the rescue shaft, so that we decided to work on two parallel rescue shafts. These drill problems were fortuitous, because in fact it would not have been safe to put through the rescue shaft a moment sooner than we did. At the end, we actually held back the drill on the lead rescue shaft for a short time, until the pumps brought the water to the safe level. We made sure the pressure was no longer elevated in the space where the miners were. Then we pushed the rescue shaft through. We lowered a microphone, which by the way a private business owner had offered to the rescue effort – just one of the many generous donations of equipment, time and energy from the whole community that contributed in so many critical ways. When he handed the earphones to Ray McKinney, and Ray verified that the miners were alive – it was an indescribable moment, just indescribable.

- **MSHA supplied the yellow rescue capsule that was used to bring the miners to the surface.** The story of that capsule is interesting. Thirty years ago, a similar capsule was used to rescue two miners in the wake of the Sunshine silver mine fire in Kellogg, Idaho – it was used to bring those two survivors from one level of the mine to another. Not long after the Sunshine Mine rescue, the present capsule was constructed, and it has been maintained for 30 years as

part of MSHA's mine emergency equipment. And for 30 years it was never used. It was periodically tested, and maintained, and you know, I keep thinking that at some time in the past 30 years, someone could easily have said, "Why are we bothering to maintain this?" Well, MSHA did maintain it, and when it was needed, the rescue capsule functioned perfectly. It was just one of many things that thankfully came together, and may it always serve as a reminder that preparation pays.

I would like to emphasize that while we in MSHA made key contributions, all the major decisions concerning the rescue were jointly agreed upon by MSHA, the Pennsylvania Department of Deep Mine Safety, and the mine operator.

At the same time, there were at least 200 people on site, and many more behind the lines working day and night in critical roles. **And all of them came through.** The teamwork was indescribable.

At the end, when we made contact with the trapped miners through that microphone and heard a voice tell us they all were alive, it was truly the greatest moment of my life. I believe many others would say the same.

We're now going all-out to prevent an incident like the one at Quecreek from happening again. We've already started our investigation of the incident. The lead investigator is Pat Brady, our District 4 Manager in Mt. Hope, W.Va., whom many of you may know.

At the same time, we're starting a national project to identify old mines. We are going to:

- Establish a task force to review the availability, accuracy and quality of old mine maps;
- Hold a technical symposium with representatives from academia, mine operators, and manufacturers on methods to accurately identify the extent and perimeter of closed mining operations; and
- Review existing Federal mine safety standards and practices designed to prevent mine inundations.

Together with the results of our investigation, this will give all of us in the mining community the information we need to prevent a recurrence of the ordeal at Quecreek.

And this review is going to encompass metal and nonmetal mines as well as coal mines.

Meanwhile, a few days after the rescue, President Bush met personally with the miners and rescuers. You may have seen the ceremony on the news.

I can tell you it was a true privilege to be there, in company with Secretary of Labor Elaine L. Chao, and to shake the President's hand. After the moment when we first reached the miners and found them alive, President George W. Bush's words of praise for our role in that rescue made it the second proudest moment of my life.

It was inspiring to hear the President speak about the wonderful spirit of the miners and all who rushed to the rescue of neighbors in danger. "I truly believe," the President said, "the effort put in will serve as an example for others in a time of crisis." He called the Quecreek rescue an example of the spirit of America. It's a spirit we know quite well throughout the nation's mining industry, wherever there has been an emergency.

The President also spoke about the technology and know-how in the field of mine safety that went into the rescue. He said, "The best of America really is the use of our technology and know-how to save lives, and to help others in need." Again, that's something that we know quite well throughout the mining industry.

Know-how, technology and teamwork – in fact, that's a perfect introduction to the points I want to bring out today—the role of education

and training, technical assistance and a new culture of teamwork—not only in responding to accidents—but in **preventing** them.

STATE OF THE INDUSTRY'S SAFETY AND HEALTH

Performance

With that, let's take a look at the mining industry's safety and health performance. It may seem rather dry after the dramatic events at Quecreek. But in terms of preventing accidents, these dry facts and figures are significant.

A few weeks ago I had an opportunity to go before a Congressional subcommittee and give a progress report on our ongoing efforts to improve miners' safety and health. I want to show you one of the charts that I showed the subcommittee, which I believe will interest you.

This chart shows a declining trend over the past 10 years in two important measurements of miner safety:

1) The percent of S&S violations, and
2) The rate of actual serious injuries.

Both of these measurements are declining—and declining in parallel. This is exactly what you would expect to see if serious mining hazards are on the decline. In other words, the Federal Mine Safety and Health Act is achieving what it was intended to achieve.

As you might imagine, one of the questions we in MSHA heard from the subcommittee concerned MSHA's commitment to enforce the law. I have said repeatedly that on my watch **there will be no less enforcement**. In fact, the overall number of violations written by MSHA increased last year.

But I would like to point out something to those who believe that there should never be any change in the number of serious violations MSHA writes, and that any decline automatically means "lax enforcement." A little thought shows that just isn't the case.

If hazardous conditions that could cause serious injuries are on the decrease, we should expect to see serious violations drop. And that is what we do see: a decrease in serious injuries and a decrease in the percentage of "S&S" violations, which are defined as violations that are reasonably likely to cause a serious illness or injury.

The purpose of the Mine Act is not to write violations. It is to reduce serious injuries and illnesses in the Nation's mines. And that is what is happening. The numbers tell the story.

The U.S. mining industry has made outstanding safety and health progress over the decades. Last year, the toll of mining deaths in this country was the lowest ever recorded. At the same time, I'd like you to notice that the graph also shows the trend is flattening. The rate of progress has been slowing for several years.

No longer are we seeing the consistent progress of earlier decades. And we have experienced some troubling setbacks. This year, for instance, fatal accidents in mines are up, compared with the same time last year: As of today, 39 mining fatalities have occurred nationwide, compared with 33 on this date a year ago.

We have seen many fatal accidents relating to human factors. Principles we need to reemphasize include staying under supported roof, locking and tagging out equipment while working on it, and properly setting brakes or blocking equipment against movement. MSHA is not going to be able to stop accidents like these just by inspecting periodically for unsafe mining conditions and writing violations.

Many mines and miners have shown good safety performance, year after year. We need to expand the circle of their success. Where safety concerns exist, we need to look more deeply into

the root causes. To do this, we need a balanced effort incorporating enforcement, education and training, and technical support, and we need to make compliance assistance a part of everything we do.

To get to the next level in safety and health, we can't just keep doing exactly what we have done before. We need to enlist the partnership of everyone in the mining industry—organizations like yours, in particular. We need a cultural change in MSHA and in the industry.

That cultural change is under way.

In MSHA we talk about three elements of success: enforcement, education and training, and technical support: each of which includes the key element–compliance assistance. Together, they form our "MSHA triangle of success."

Most importantly, as I have told MSHA employees around the country, we need to be "one MSHA"–not a collection of separate organizations or programs working at cross-purposes, as has happened sometimes. The mining industry should have just one MSHA to deal with, one organization and one message, one set of standards and one set of policies. We have charted a course for improvement, and we are under way.

THE MSHA TEAM

In the 15 months that I have directed MSHA, an important concern has been building the MSHA team. An increasing number of MSHA's senior managers are eligible to retire. This reflects a trend throughout the whole Federal government. The rebuilding process has begun, and it is a critical step for long-term success.

You'll also notice that an increasing number of our managers are Certified Mine Safety Professionals, reflecting their commitment to a high stand of professional knowledge in their field.

John Caylor has been our Deputy Assistant Secretary for Policy since last October.

A safety and training executive with 30 years experience in industrial health and safety management, he most recently served as Vice President, Safety and Training, with Crescent Technology, Inc., an international consulting company providing professional safety and training services.

He has extensive safety and health management experience in the mining industry here and overseas with companies, including Magma Copper, Anamax Mining Company, Cyprus Minerals, and Freeport-McMoran, Inc. He belongs to numerous professional and industry organizations, is a Board Certified Safety Professional (CSP) and a Certified Safety and Health Manager (CSHM). He holds a Bachelor of Science degree in Business Administration from the University of Phoenix, Phoenix, AZ.

John R. Correll recently joined us as Deputy Assistant Secretary for Operations. John brings extensive knowledge and experience to the position. Since 1991 John was Director of Safety for Cleveland-Cliffs, Inc. Previously he worked 11 years with AMAX Coal Industries as Director of Safety & Workers Compensation in Indianapolis, and 5 years with Peabody Coal Company as Arizona Division Manager of Safety. He holds a B.S. degree in Safety and Environmental Management from Indiana State University. He is an M.B.A., a Certified Mine Safety Professional and a Certified Safety Executive.

I have also filled our two Administrator positions for Coal Mine Safety and Health and for Metal and Nonmetal Mine Safety and Health.

The position of Administrator for Coal Mine Safety and Health Administrator has been filled by Ray McKinney. Ray has been with MSHA

for more than 25 years Ray has directed and participated in several rescue and recovery operations before Quecreek, and received the Department of Labor Valor Award for the safe rescue of a trapped miner at the Upper Taggart Mine in 1979.

Our new Administrator for Metal and Nonmetal Mine Safety and Health is Bob Friend. Bob has been with MSHA for almost 25 years, most recently serving as Deputy Administrator, and many of you know him well. He was well prepared to step into his new role.

Along with their other qualifications, both Ray and Bob are Certified Mine Safety Professionals.

In Coal Mine Safety and Health, we also have filled the positions of Director of Safety and Director of Health. Our new Director of Coal Mine Safety is Michael Miano. Mike worked in the coal industry for 27 years, holding key management positions in major companies. He then joined the State government in West Virginia, where he had responsibilities for environmental and transportation issues. He holds a bachelor's degree in Mining Engineering. Among others distinctions, in 1991 he was recipient of American Electric Power's Chairman Award for Underground Mine Safety.

Our new Director of Coal Mine Health is Melinda Pon. She has a bachelor's degree in Biological Sciences and a master's degree in Public Health. She has extensive experience in strategic, technical and public policy issues related to safety and health, and has an impressive history of working relationships and affiliations with worked with mining companies, associations and scientific associations here in the U.S. and abroad.

Filling these and other key management vacancies in MSHA has been a critical step because these highly qualified team members have key roles as we move to implement our management goals.

SETTING THE COURSE

Like all Federal agencies MSHA is working under the umbrella of the President Bush's long-term management agenda for improving the overall management and performance of the Federal government.

Within that framework, Secretary Chao established a strategic plan for the Department of Labor. Prominent in the Secretary's plan are Quality Workplaces. That means workplaces that are safe, healthful, and fair.

In this context we set specific goals in mine safety and health:

- Reduce mining industry fatalities by 15 percent per year;
- Reduce lost-workday injuries by 50 percent over four years;
- Reduce coal mine dust and silica samples indicating overexposure by 5 percent, per year;
- And reduce noise samples that indicate overexposure by the same amount.

We also set goals for reducing accidents and workers' compensation costs within MSHA so we can lead by example and improve our financial management. Moreover, as you know we held general stakeholder meetings in all of our 17 districts across the country last year, and special stakeholder meetings on education and training issues and on information technology. These had a tremendous response from all sectors–management, miners, industry and labor groups, and safety professionals. I held similar meetings with MSHA employees throughout the country.

From there, we developed a roadmap for MSHA, a set of initiatives and prerogatives for MSHA in the 21st Century that covered several key areas including enforcement compliance assistance, education and training, small mines and use of data. For the past several months we

have been sharing these initiatives with stakeholders across the U.S., and I would now like to update you on our progress in implementing them.

Enforcement

First, enforcement. Again, we have emphatically **not** reduced enforcement at MSHA. In fact, the number of inspection hours per mine increased last year.

At the same time, we're moving to improve our enforcement. We're correcting some inconsistencies that have existed in MSHA's enforcement patterns. We're looking closely at ways to make the best use of time during inspection visits. And, we're making long-term improvement to the fundamental training our compliance specialists receive. We are teaching them how to analyze a mine's record before they make a visit, how to identify root causes of problems, understanding the human factor, and how to communicate most effectively with both management and miners.

Compliance Assistance

Compliance assistance is absolutely vital throughout the U.S. Department of Labor. For instance, Secretary Chao has created a new, permanent, senior position in the Department: a Director of Compliance Assistance. She also established a new toll-free call center for the entire Department -- one stop shopping for information.

You may never need that toll free number to reach us in MSHA, because we already have close working relationships. But all over this country are employers and employees who may be unclear about their responsibilities or the services available to them. There had never been one central number they could call. Now there is one.

And Secretary Chao emphasizes that the toll-free call center does not have "Caller ID." So no one will ever be fined for asking a question! That call center indicates how seriously the whole Department of Labor is taking compliance assistance.

Our district personnel have taken the compliance assistant message to heart. I wish you could have been with me at a recent senior staff meeting. Once a month we have a meeting in which all our district managers around the country participate by conference call. Hearing their reports, we know it is working. We are making compliance assistance a part of every mine visit. And in district after district, managers report special cooperative efforts at mines that are most in need.

At these mines, MSHA's compliance personnel are working together with mine operators and miners to identify roots causes of accidents and create training programs addressing those root causes. Some mines are reporting improvements in safety performance. And I would like to mention that some CEO's have become personally involved in these efforts – which is absolutely the gold standard. There is nothing like involvement by the CEO to guarantee a high level of attention to getting results.

Moreover, we are taking steps to make MSHA's culture change, so that compliance assistance will be remain a key aspect of everything the agency does in the future.

Education and Training

In education and training, we are making a complete review of our existing materials and updating them.

We are systematically updating all our training films, transferring them to DVD, and developing new programs directly on DVD. We

expect soon to release our first web-based interactive training program, on MSHA's new HazCom rule.

We're looking into simulators that can assist in training miners in new tasks. And we are exploring the potential of safety training methods used in the military.

We are also moving to translate training materials into Spanish. We now have Best Practice reference cards for miners available in Spanish on a wide range of safety topics. Ultimately, we plan to have 120 publications and 26 videos translated into Spanish. Our website is now available in Spanish, also.

To assist mine operators in developing training plans, MSHA developed a Starter Kit that contains a training plan for mine operators to use as a template. We provide compliance assistance as part of the training plan review and approval process.

We worked with one mine operator to develop a comprehensive training program in health and safety for all 700 of the company's supervisors. This included classroom and hands-on training at the National Mine Health and Safety Academy, and follow-up in the mines. This approach has potential to benefit other operations.

And, we're trying new way to reach miners directly— for instance our explosion propagation demonstration that has been on the road taking the safety message to miners throughout the country.

Small Mines

Secretary Chao has emphasized compliance assistance to small businesses, and in all of our activities we are giving special attention to the needs of small mines.

Small mines are more likely to be without professional safety staff and have fewer resources. By this autumn, we will open a small mine safety and health office that will be devoted entirely to assisting the small mine operator.

In addition, we are developing a "small mine starter kit" to provide everything a small mine operator needs to know about MSHA. This helps small operators who can feel overwhelmed in trying to sort out what they need from all the available information.

Small mines also can have special conditions in which a one-size-fits-all approach doesn't make sense. For instance some months ago, we were approached by a group of small operators of bluestone mines in the Northeast United States.

We talked with them, visited the quarries, and found that these small mine operators were understandably confused and frustrated with some of the extensive MSHA requirements. As one example, they pointed out that MSHA required a stretcher to be available, even in a one-man operation!

Since then we've provided extensive compliance assistance to these small quarries, we are exploring ways to provide more flexibility, and the quarry operators have expressed their appreciation.

Use of Data

In line with President Bush's emphasis on e-government, we are moving forward rapidly to provide more data and services on MSHA's website. Here are some examples:

- We have placed data prominently on our website concerning the most frequently cited violations in each sector of the mining

industry. We're developing compliance tips to go with them.

- We have redesigned the MSHA web page in line with the Department of Labor web page and made it easier for stakeholders to find materials they need.
- We've established a system for to assure prompt and accurate turnaround on e-mail inquiries to the MSHA website.
- We're developing a system for maintaining e-mail mailing lists to distribute Fatalgrams, policy letters, news releases and other timely materials.
- We're expanding the electronic filing of forms, with the goal of moving away from paper filings.
- And in our rulemaking projects, we're placing all public comments on the MSHA website, where they are easily available to stakeholders.

Regulatory Issues

This brings me to rulemaking activities. As you know, last year we shortened the list of rulemaking projects on our semi-annual regulatory agenda. Many items had been on the list for years, without progress. We have fewer regulatory items, and we are moving forward on them.

Whenever we take action on a rulemaking, there has to be a real need, and rulemaking has to be the most appropriate solution. We will always request and thoughtfully consider input from our stakeholders to develop the most effective and workable rules for protecting miners' safety and health. So far as possible we will work towards general agreement in rulemaking, with an outcome that all parties can accept as necessary and practical. Finally, we've made compliance assistance as an integral part of the rulemaking process.

As an example, take our HazCom rule – which was recently published in the Federal Register. As you know, that rule was originally published late in the year 2000 as an "interim final rule." Last year we reopened the rulemaking record and held seven additional public hearings to make sure there was ample opportunity for public comment on the rule before it became effective. The final rule reflects the input we received and has some significant differences from the original "interim final" rule. We also paid special attention to the special needs of small mines. The effective date for most mines is three months from publication, but for the smallest mines-- those with five employees or fewer-- the effective date is 9 months from publication.

We have now held 15 national informational meetings to help the mining industry comply with the HazCom rule – including one recently in Norton, Virginia. We're providing a detailed, readable guide to understanding HazCom; PowerPoint presentations; and a self-paced, interactive guide that will explain all sections of the regulation. We also intend to conduct compliance assistance training during every mine's first inspection under the final rule. We are committed to providing compliance assistance on HazCom to every mine operator who requests it.

In another step forward, we recently reached a second interim agreement with industry and labor concerning the agency's standard on diesel particulate matter (DPM) at metal and nonmetal mines. I'm gratified that industry, labor and MSHA were able to come together to resolve differences. It shows what we can do when we work together toward a common objective.

Under a previous agreement, we conducted joint sampling with industry, labor and government at 31 underground mines to determine existing concentration levels of diesel particulate matter and to gather information about the feasibility of complying with the

standard's concentration limits in the underground mine environment.

For the next year we will work intensively together to reduce exposures to diesel particulate matter that increase the risk of lung disease in miners. We also will reenter rulemaking on several provisions in the metal and nonmetal DPM standards.

Among other rulemaking projects that are ongoing, we are taking another look a new rule to allow mine equipment to be tested for approval purposes by independent labs. We also are engaged in an extensive, long-term effort to review existing regulations and policies in line with the President's goals. The aim there is to identify provisions that are outdated, redundant, unnecessary or otherwise require change.

In all of these projects, we want your input – and input from the whole mining community.

ENGAGING COMMITMENT

I want to thank those of you who are participants with MSHA in all these activities, and who exemplify health and safety excellence. You are showing the way to others. Those mines that do well in safety always have one thing in common: they make safety a value.

It is one thing to have information about how to keep mines safe and healthy. And we are working very hard to make that information available throughout the mining industry. But information is just the beginning. There has to be a habit of doing the safe thing, a habit so ingrained that safety has become a value. It is also a value that needs to come from the top – from those of you who are leaders of your companies. If you are giving this leadership, from the top down, setting specific safety and health goals and monitoring performance, making it clear that safety and health are part of the triangle of your business success, then you know that it gets results. It's all about results! You also know that positive safety and health performance enhances efficiency, productivity, and even profits. From every point of view, safety is a value.

LET'S SHOW WHAT WE CAN DO– TOGETHER

As you look at MSHA, you should now be seeing an agency that:

- Goes beyond traditional enforcement mechanisms;
- Emphasizes human factors;
- Searches for new methods and technological innovations;
- Fosters a culture of health and safety excellence; and
- Collaborates with and listens to our stakeholders -- the citizens.

All this is good for miners, and good for everyone. And we are inviting and counting on you to help lead the way -- not only in the mining industry, but also for all Americans.

Does that seem like an overstatement?

One of MSHA's employees recently showed me a letter to the editor about the Quecreek rescue. A gentleman in Cherryfield, Maine, wrote as follows:

"This story has everything that is good about America...What we witnessed was the ultimate American spirit in action. Those who hate us can hijack planes, destroy buildings, set off bombs, and kill hundred of Americans. But as far as breaking the American spirit, they don't have a chance. I am proud to be a citizen of a

nation where common people, united in spirit, could pull off the type of rescue that ended in triumph in Pennsylvania."

What we do in the mining community, the spirit we show, the way we work together, really can have an impact far beyond ourselves and our industry. Relatively few of us may have the opportunity to take part in such a frankly dramatic situation as Quecreek. However, we all have the opportunity to bring the same passion and commitment to our fellow Americans to the task of **preventing** injuries, illnesses and fatalities in the Nation's mines, that we have brought -- over and over -- to our response in mine emergencies.

Success in reaching the next step in mine safety and health will require everyone's commitment and most importantly, our performance. Let's show the world what we can do–together.

Thank you, and God bless America.

KEYNOTE SPEECH: HEALTH AND SAFETY'S ROLE IN A CHANGING INDUSTRY AND CHANGING WORLD

Mr. Charles Hawkins

Executive Vice President and CEO
National Stone, Sand & Gravel Association

Thank you Tom (Novak), it is a pleasure to be here, although I feel a little like a duck out of water when I review the impressive list of participants.

Mr. Secretary (Dave Lauriski) it is always a pleasure to be with you. Let me add to the other accolades which your agency has received for the rescue in Pennsylvania – we all realize that it was a massive effort on the part of MSHA, the local operators, state officials and yes the nine miners who were trapped, but it does emphasize the importance of good preparation and practice. The National Stone, Sand & Gravel Association is the result of the merger of the National Aggregates Association (formerly the National Sand and Gravel Association) and the National Stone Association (formerly the National Crushed Stone Association and the National Limestone Institute) in 2000. With the merger just two years ago you will find it interesting to note that we will be celebrating 100 years of national associations serving the aggregates industry in 2003 – that stems from the fact that the first organized national association was the National Quarry Producers Association which met in 1903 in Chicago.

NSSGA has approximately 850 member firms, about half of those involved in the actual production of aggregates. The producing members account for 90 % of the annual crushed stone production and in excess of the 75% of the sand and gravel production. During 2001, 2.78 billion metric tons of crushed stone, sand and gravel, valued at $14.5 billion, were produced and sold from 10,000 locations nationwide – more than double the tonnage of the next largest mining sector. As all in this audience are aware, the industry has several thousand small businesses to which just operating every day is a challenge. The industry's market is easily segmented into five general categories – 40% of the production goes to highways and related infrastructure, 20% goes to residential construction, another 20% to commercial construction (shopping centers, office buildings, industrial parks, etc.), 15% to other public works projects, i.e. water and waste treatment facilities, schools, hospitals, etc. and the remaining 5% to specialty products including agricultural fertilizers, landscaping, glass, fillers for paint, toothpaste, chewing gum, etc. It is a product, which for the most part is not a consumer or retail commodity and therefore not understood. When you look at asphalt, do you know that 94% is aggregate? When you look at a concrete building is the first thought that crosses your mind is that 80% of that concrete is really aggregate? Probably not.

As noted in my introduction I have spent my entire career since returning from Vietnam in 1968 representing management to the Federal government. Specifically the management of construction materials producers (sand, gravel

and crushed stone) and construction contractors. During that time period we have lived through:

- The development and implementation of the regulations under the 1966 Federal Metal and Nonmetallic Mine Safety Act – an act which first recognized the need for separate treatment of sand, gravel and crushed stone operations by creating Part 56, and even conceding that underground stone operations were different in many respects and recognizing that in some of the regulations. That rule developing process included the incorporation of the safety standards which had been promulgated under the Walsh Healy Public Contracts Act along with some other consensus standards;

- The adoption of the federal Construction Safety Act in 1969, which was quickly incorporated into OSHA after its enactment;

- Passage of the Williams-Steiger Occupational Safety and Health Act. As a young lobbyist at the time, I got to know Congressman Steiger and claim credit (I am sure with many others) for the inclusion in the final legislation that all important comma which had the effect of excluding from coverage under OSHA, industries which were subject to other federal statutes (mines, railroads and utilities);

- Amendment to the Coal Act to merge it with the Federal Metal and Nonmetallic Mine Safety Act, transferring the new agency from the Department of the Interior to the Department of Labor in 1977. Congressman Ron Sarasin from Connecticut was the ranking member of the subcommittee of jurisdiction at the time. Ron, who is currently the President of the U.S. Capitol Historical Society and I were reminiscing about those days not long ago;

- That legislative action of merging the two acts together led to what the aggregates industry believed was the egregious action to force them to conduct training in the same manner as the underground coal operators. A lawsuit resulted and three years later an appropriations rider which exempted the industry from training standards until the adoption of Part 46 three years ago. I should note for historical purposes that the industry lost the litigation, but delayed implementation of the standards long enough to make its case on Capitol Hill achieving the rider.

> *Speaking of litigation, Secretary Lauriski, perhaps you will be pleased to learn that while the industry has another eight days in which to challenge the new Hazard Communications standard in court, NSSGA does not intend to do so. We are committed to helping the industry comply!*

Earlier this year we conducted an extensive survey to identify the Top 10 Challenges and Opportunities for the Aggregates Industry. While several of those identified address markets (future highway funding) and dealing with a volatile economy and the debate of "quality growth" vs. "smart growth," there were also concerns about stable and reliable supplies of energy (and water in the West). High on the list is the need for regulations to be based on sound science with realistic cost-benefit analysis as well as mitigating the disproportionate impacts of government actions on small business including the frequently overwhelming burden of paperwork which becomes a nemesis in its own right.

A number of the identified "challenges" have a direct relationship to safety and health. One of those reads "Operating profitably with a top priority commitment to safety and health of workers, including active commitment to voluntary company occupational health programs." "Profit" is not a dirty word and without it there are no jobs, taxes and all of the related spin-off benefits. With the industry evolving to many more publicly held companies, bottom line results have a higher profile than when the industry was predominately privately

held and there were many ways to realize economic gain. There is a high commitment to the safety and health of the workforce, not just because it is the right thing to do but also because it contributes measurably to the bottom line. Likewise there is a growing commitment to companies engaging in an occupational health programs taking a proactive attitude rather than a reactive one.

Without question the industry's most valuable asset is its workforce. Recruiting and retaining a quality worker has become one of the biggest challenges for all companies. Whether we like it or not, we are not the employer of first choice for many who end up working for the aggregates industry. This has several very direct impacts on safety and health. Obviously training a worker to protect him/herself, much less those around them, is a first priority. Beyond that, task training is very significant – the equipment which is now used in operations is expensive and must be used properly and maintained in order to achieve the return necessary to justify the capital outlay. Safe, efficient and productive operation are absolutely necessary, to do otherwise is unacceptable. In a few moments I would like to discuss several other ramifications of this worker issue in the light of the Rand Report.

But, there is another issue related to the work force situation which is a challenge to all of us concerned with safety and health in the aggregates industry. With the shortage of skilled workers the industry has turned to using contractors to perform many tasks – drilling, blasting, overburden removal and more recently to contract crushing-screening and subsequent processing. The introduction of contractor employees to a work site challenges both the mine operator and the contractor to insure a safe and healthy work environment. It is a fact of life and we must all find effective ways to deal with it.

The final "challenge," we identified which I believe has a very dramatic impact on the future of this industry and certainly has significant safety and health implications. Operating permits, whether federal, state or local are without a doubt the single biggest impediment to the industry's success today. The very nature of the product, heavy loading, low value necessitates that it be produced close to the point of consumption – generally within 50 miles. This leads to conflicts with neighbors, communities and various groups of antagonists every time there is an attempt to renew, expand or open a new location. Note if you will that all of the acquisition activity, which has been going on for the past 15 years in the industry almost without exception, includes reserves, which have already received operating permits.

The industry will develop and operate more underground mines in order to deal with the neighbors in the future. Operating in an underground environment is by its nature a greater challenge to safety and health, we will need to focus attention on those operators who are new to this environment. It will challenge the regulated and the regulators.

Turning to the Rand Report, titled "New Forces at Work in Mining: Industry Views of Critical Technologies, 2001." The report was commissioned by NIOSH, received funding from DOE and organizational support from the White House Office of Science and Technology Policy. Its findings were derived from confidential discussions with leading representatives of 58 mining firms, equipment manufacturers, research institutions and others. Included were aggregates industry executives from the three largest companies, Vulcan, Martin Marietta and Hanson. The study identified four drivers for future technological changes including;

1. Lowering production costs
2. Enhancing the productivity of workers and equipment
3. Extending the life of existing quarries and opening up new reserves, and
4. Continuing to meet regulatory and stakeholder requirements for safety & health, environmental impacts and land use.

The report noted, "Due to the financial prospects, rapid consolidation and a less-advanced technology baseline, the stone and aggregates industry should see the fastest pace of technological change in any mining sector in the coming decades. Stone and aggregates producers stand to become important drivers of mining technology innovation because they will be driving the purchase of new machinery and equipment."

What the report misses, in my opinion, is the tremendous impact that the shortage of skilled workers has already had on automation of existing operations. Operating multi-million ton per year plants with a couple of men per shift and a maintenance crew was unheard of a decade ago. Today it is reality. Safety and health statistics will improve, if or no other reason, because there are fewer man-hours of exposure.

Finally, the Rand Report notes that the regulatory framework in some areas, such as ground control, is outdated and hence of limited relevance to emerging technologies. It also observes that some mining regulations such as those dealing with ambient noise and respirable dust are technologically impossible to achieve. Regulators face serious challenges to their credibility when they fail to recognize the technological impracticality of some of their proposals – when this occurs industry tends to treat all of the proposals with mistrust.

Rand does acknowledge that the workforce is aging and this in its own right raises concerns about the longer injury recovery times and more lost time due to non-mining related medical concerns. Couple this with industry's concern with risk management (avoiding costly and time consuming lawsuits and litigation), improving productivity while maintaining high morale and you begin to understand some of the conflicting pressures of operating an aggregates production facility.

There remains much that the industry in cooperation with experts from academia, government and our suppliers can do to continue to improve the work environment for our greatest assets – the worker. All must recognize the changing face of the workforce, recognizing the roles that women, and minorities must play in the future. Addressing the diversity issue is not for the future, it is for now and should have been recognized several years ago. I hear of contractors establishing day care centers at large job sites and aggregate producers conducting training in Spanish while requiring Spanish speaking foremen and superintendents at certain plants – we are changing, but there is much more to do.

For industry to accept changes in the current regulations applicable to aggregate operations or proposed new ones there must be sound science justifying the change not the whim of an individual or small group. Honestly, it is difficult to understand much less communicate to an industry why an agency would go forward with a proposed regulation when another agency is involved in basic research having direct bearing on the particular situation, such as we have seen in the diesel rule process.

The cooperative (including collaborative) rule making atmosphere goes a long way toward building trust. There will always be issues where there is disagreement over what is necessary versus what would be nice. Look at the emotional debate on ergonomics with strong positions staked out by regulators, labor and industry – it is a legitimate debate, this great country conceived a system of government that encourages debate and in the end a resolution probably not totally acceptable to any of the parties will emerge.

There are several definitive steps, which need to be taken to continue this open dialogue. First, the aggregates industry needs and deserves at least one and possibly more seats on the Federal Mine Safety and Health Research Advisory Committee for which NIOSH provides secretariat support. Second, we must find ways to provide additional non-threatening (consultative) inspections for aggregate operations. The current program of offering a

consultative inspection before start up when there is a change of ownership of an operation is a step in the right direction. We can do more by funding to the legislated limit ($10 million annually) of grant funds available to states. Third, we must find a way to reduce the paperwork – it doesn't reduce accidents and harasses the small operator. The last three administrations as well as the Congress have expressed concern about the burden of paperwork on business in general and small business specifically. I am deeply concerned about the implementation of the new HazCom standard and its paperwork requirements.

Ultimately, we must find a vehicle for concentrating on the bad apples and rewarding the good. I recognize the constraints of the law, but a program such as exists under OSHA, barring routine inspections of operations who beat the industry injury incidence rate average is a model to examine – they are not exempt from inspections generated by a complaint, a multiple worker accident or a fatality – this type of recognition would go a long way toward encouraging operators to strive for a better work environment.

The aggregates industry is and will continue to grow – it is estimated that during the next 25 years we will produce more product than was produced during the last century. The industry has recently been "discovered" by academia as an employer for graduates and concern over the future availability of sufficient high quality material. Simply stated the infrastructure of this country and others around the globe depends upon the industry's products.

All of us—the industry, the regulators and labor—have one goal in mind: the safety and health of our work force. There is room for debate, and our system permits, even encourages it. But, let us not challenge each other's motives, it does no good and simply is not the truth. If we continue the open, honest dialogue that has been the hallmark of the last two years, there is nothing that we cannot accomplish. Thank you.

CHALLENGES AND OPPORTUNITIES FACING THE MINING INDUSTRY IN THE QUEST FOR IMPROVED SAFETY

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Office for Mine Safety and Health Research
Washington, DC

INTRODUCTION

This paper begins by looking at the vision and mission of the National Institute for Occupational Safety and Health (NIOSH), particularly the mine safety and health research program. Next, current employment within the mining industries is examined. The paper then focuses on trends within the mining industries, with particular attention to workforce trends, workplace trends, and operational trends.

Next, health and safety issues within the mining industry are examined. Health and safety data on fatalities, injuries, and occupational illnesses within the mining industry are reviewed.

Published opinions of others with regard to directions or concerns for the mining industry in the future are explored. The paper concludes with the author's view of the challenges and opportunities facing the mining industry in the quest for improved safety.

NIOSH VISION AND MISSION

The vision of NIOSH is—Delivering on the Nation's Promise: safety and health at work for all people through research and prevention.

The Office for Mine Safety and Health Research within NIOSH undertakes its activities consistent with the following mission: to provide national and world leadership to prevent mining work-related illness, injury, and death by gathering information, conducting scientific research and demonstrations, and translating the knowledge gained into products and services. It is important to note that the work of NIOSH does not end with the conduct of research or the gathering of information. Rather, it must go beyond to translate that acquired knowledge into products and services that can make a real difference for industry in general and the mining industry in particular.

THE CURRENT MINING INDUSTRY

Table 1 shows the current number of employees in the U.S. coal industry; the metal/nonmetal industry; and the sand, gravel, and stone industries. These employment figures are broken out for both surface and underground. It is interesting to note that the three segments of the mining industry (coal; metal/nonmetal; and sand, gravel, and stone) all employ about 100,000 workers each. This reality causes NIOSH to consider all mining segments of equal importance as it plans and conducts its research programs.

Table 1. Employees in the Mining Industry

Current Industries
(Number of Employees)

	Coal	Metal and Nonmetal	Sand, Gravel and Stone
Surface	55,999	88,886	105,863
Underground	46,297	12,633	2,197
Total	102,296	101,519	108,060

INDUSTRY TRENDS

In looking for opportunities to conduct health and safety research, NIOSH looks at the coincidence of workforce trends, workplace trends, and operations trends. As shown in Figure 1, consideration of all three factors provides NIOSH planners with the correct focus for its mine health and safety research program.

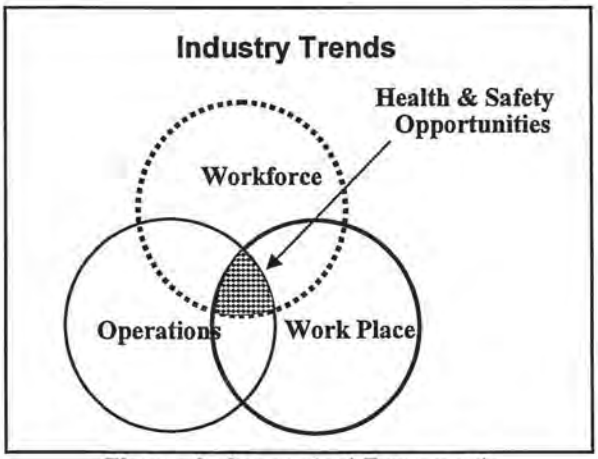

Figure 1. Conceptual Framework

Workforce Trends

The U.S. mining workforce is changing. U.S. miners are getting older. The average age of a coal miner in this county is approaching 50 years of age. Turnover among new miners is high. As many as 80% of new miners entering the workforce leave quickly.

Many new miners are Spanish-speaking. English as a second language is a growing concern in the U.S. mining industry. There are increasingly higher percentages of women in the mining workforce.

Figure 2 breaks down employment in surface mines by various categories. It is noteworthy that the largest single category of employment is within the stone industry (30%).

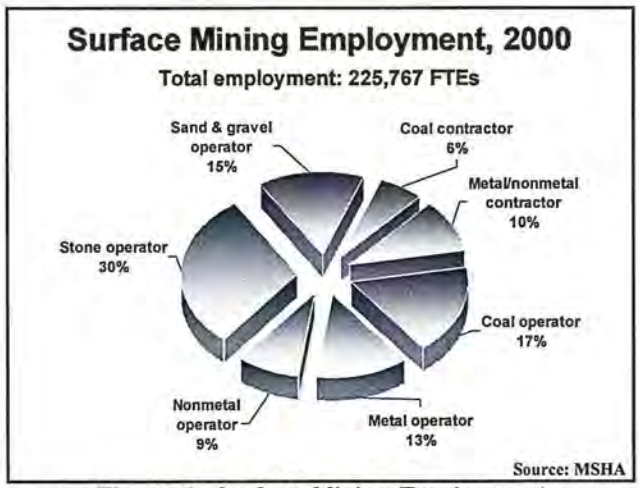

Figure 2. Surface Mining Employment

Figure 3 looks at underground mining employment. Coal operators at 69% are far and away the largest category of employees for the underground mining industry.

Figure 3. Underground Mining Employment

Figure 4 examines employment trends within the surface mining industry for the period 1991-2000. It is noteworthy that there are increases in all of the contractor categories from 1991 to 2000. The role of contractors in the mining industry is growing, which brings its own special issues and challenges.

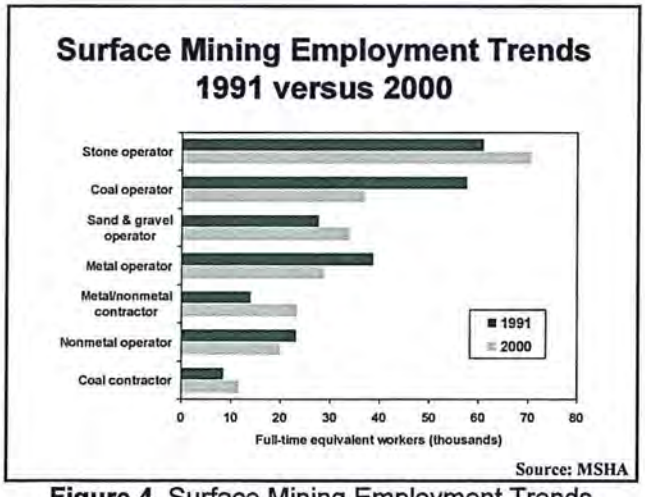

Figure 4. Surface Mining Employment Trends

Figure 5 looks at employment trends from 1991 to 2000 for underground mining. There is a notable decrease in coal, metal, and nonmetal operators, whereas the number of contractors is increasing in underground mining.

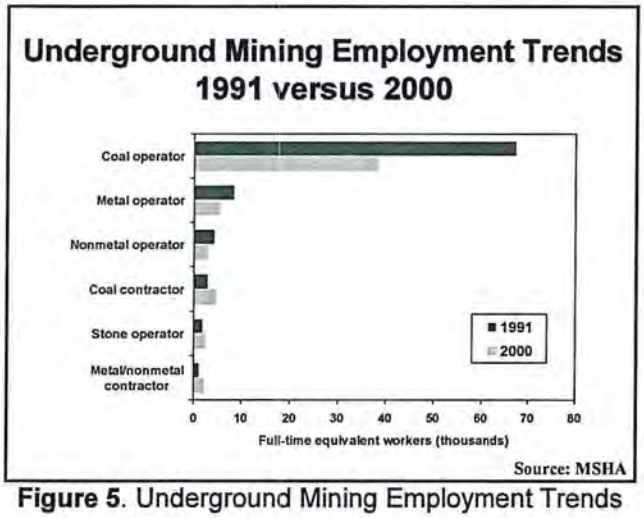

Figure 5. Underground Mining Employment Trends

Workplace Trends

The number of mines and prep plants in the United States is decreasing. Figure 6 shows this declining trend over the past 20 years. Conversely, the dimensions of many of our mines are increasing. One need only look at the size of longwall panels used to mine underground coal as an example of this significant increase in size.

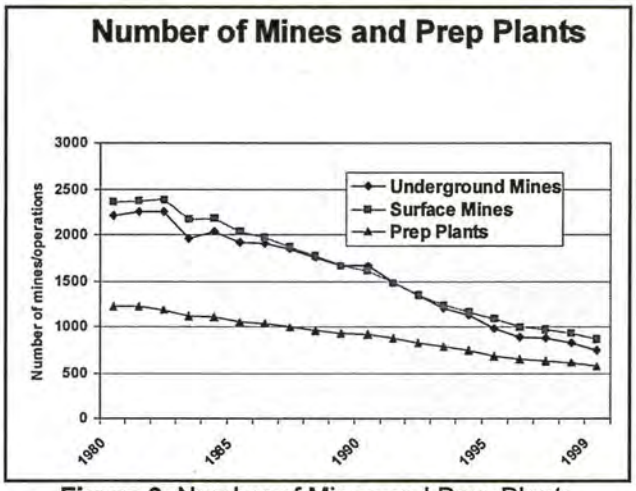

Figure 6. Number of Mines and Prep Plants

The conditions in which we must mine are becoming ever more difficult and challenging. Previously, we mined the reserves closer to the surface. Now we are continually going deeper, encountering the problems of higher stresses and more difficult geologic conditions.

In the United States, a number of stone operations are moving underground to be more environmentally acceptable and to maintain a "good neighbor" relationship to the local communities. This movement to underground operations creates increased health and safety challenges not faced during surface mining. It is also noteworthy that many sand and gravel operations are small. This brings particular concerns to those addressing health and safety problems in the stone industries.

Operational Trends

Production in underground coal mines has seen tremendous increases in recent years. Figure 7 shows the increases in longwall production from 1970 to 1999. In this case, there has been an almost tenfold increase in production.

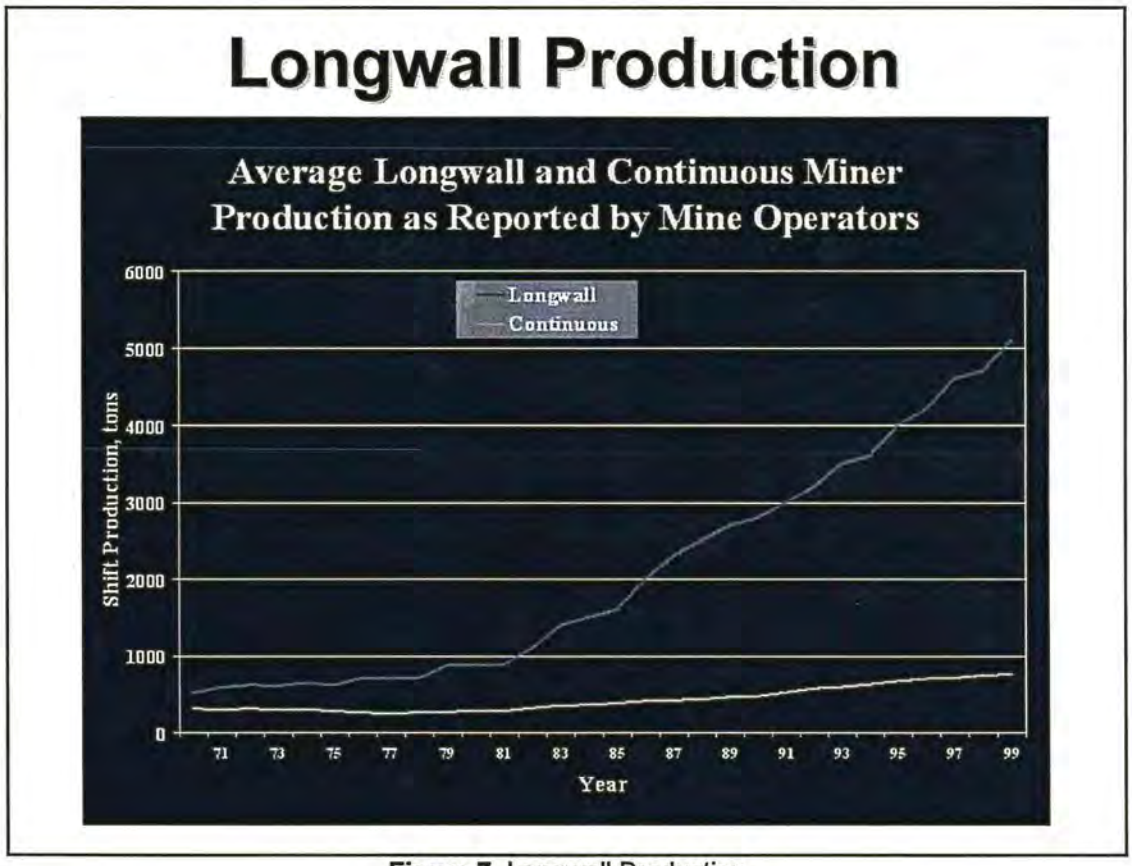

Figure 7. Longwall Production

Fewer workers produce more products in mines in the United States, a testimony to operational efficiency and worker accomplishments. Figures 8 and 9 show the

accomplishments by the mining community as the number of workers has decreased and the productivity per worker has increased dramatically.

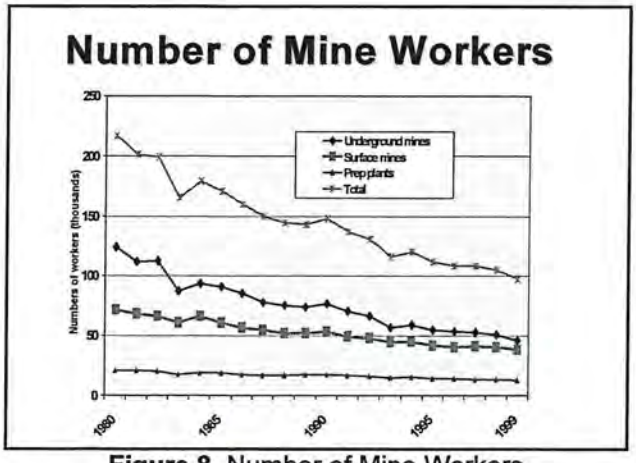

Figure 8. Number of Mine Workers

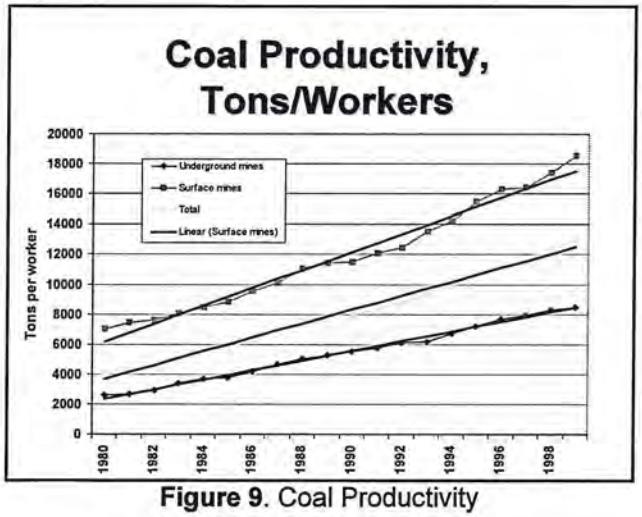

Figure 9. Coal Productivity

The equipment used in mining is getting ever larger. The average capacity of a haul truck has doubled in size over the last 15 years. It is currently projected that haul truck capacity could reach 1,000 tons by the year 2020, yet another doubling in size.

The use of diesels in underground mines is increasing. Although diesels are widely used in metal/nonmetal mines, they are now finding there way in increasing numbers into underground coal mines. Pennsylvania has recently allowed the use of diesel engines in underground coal mines. It is likely that West Virginia will follow suit.

Another operational trend is the increased use of extended work shifts. Shifts longer than 8 hours are becoming much more common within the mining industry. Some operations have gone exclusively to 12-hour shifts.

Selected Health and Safety Trends

In this section, we will examine certain trends in the health and safety performance of the mining industry.

Figure 10 looks at the average annual fatality rates for mining industries versus all private industry within the United States. It is alarming to note that for coal mining, for example, the average annual fatality rate is six times that of all other industries within the United States. For metal/nonmetal, the rate is five times as great.

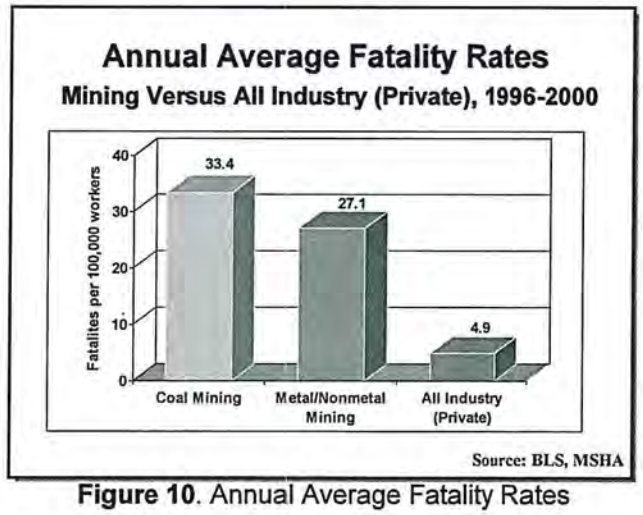

Figure 10. Annual Average Fatality Rates

Figure 11 looks back over the last 35 years at the decline in the average number of fatalities in the mining industry. The mining industry has much to feel good about in terms of working on its health and safety issues and seeing tremendous improvements.

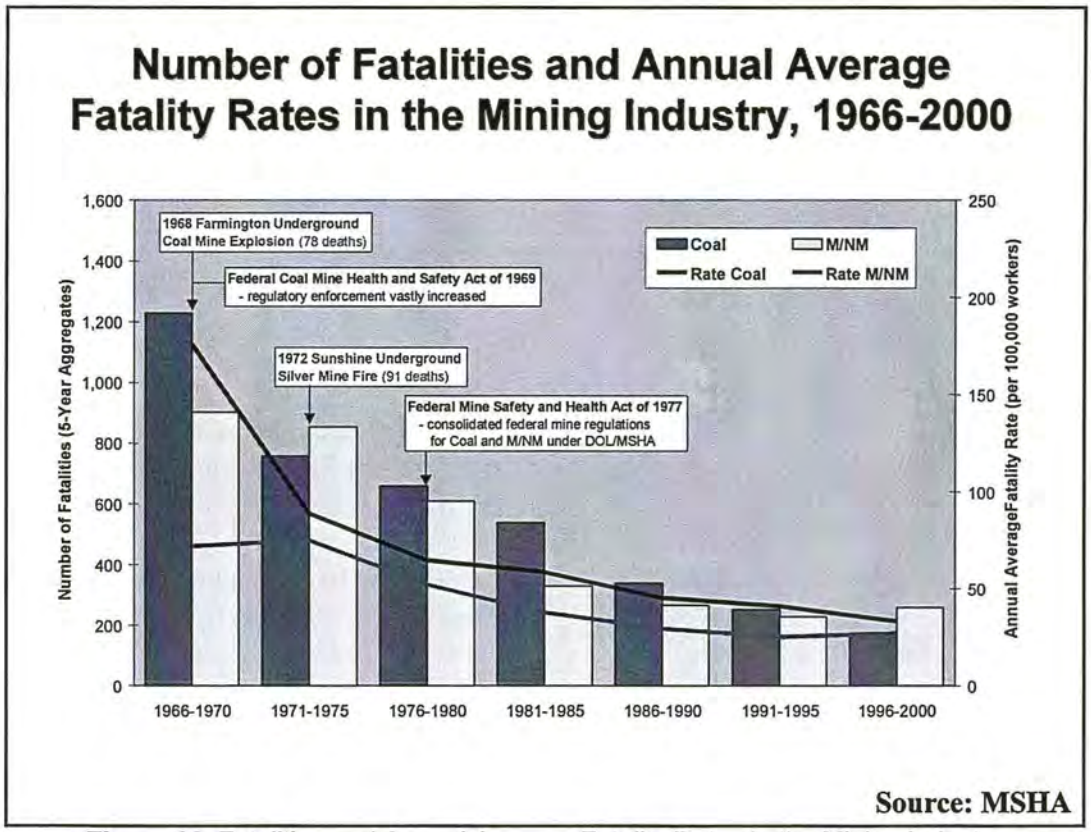

Figure 11. Fatalities and Annual Average Fatality Rates in the Mining Industry

Figure 12 takes a more recent snapshot looking back to 1981. Here we see a leveling-off in the rate of decline of mining-related fatalities.

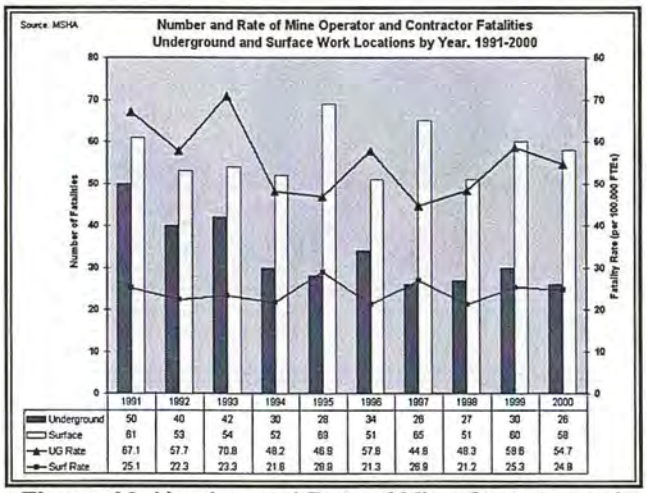

Figure 12. Number and Rate of Mine Operator and Contractor Fatalities, 1991-2000

Figure 13 examines the causes of accidents that have led to underground mining fatalities. Not surprisingly, in underground mining, falls of ground predominate with 50%. However, powered haulage at 23% is a major contributor as well.

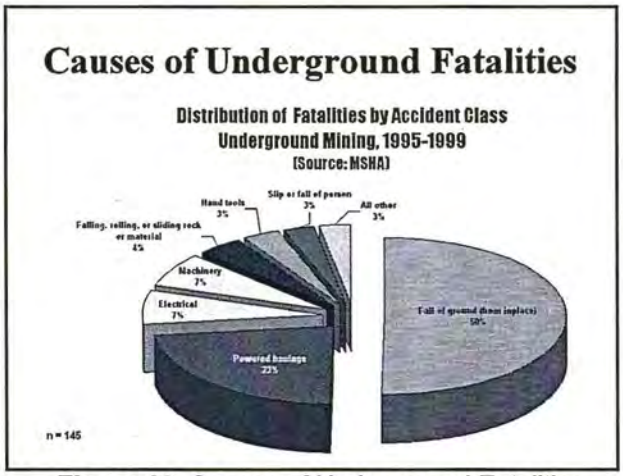

Figure 13. Causes of Underground Fatalities

Figure 14 looks at causes of surface fatalities in the mining industry. Powered haulage, machinery, and slips and falls are the largest three categories.

Figure 14. Causes of Surface Fatalities

Figure 15 looks at lost-time nonfatal injury and illness rates for coal mining and metal/ nonmetal mining versus all private industry within the United States. Coal mining, by a factor of 2.5, has higher injury and illness rates compared to all industry within the United States.

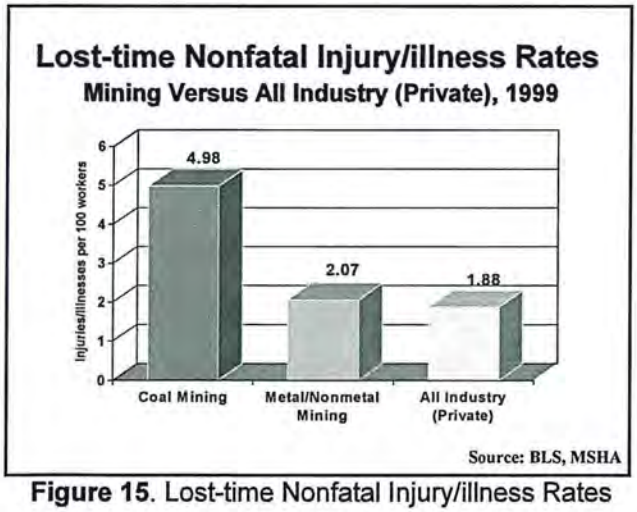

Figure 15. Lost-time Nonfatal Injury/illness Rates

Figure 16 shows that not only is there a greater frequency of lost-time injuries and illnesses in the mining industry, but the severity, measured by the median number of days lost for each injury and illness, is also much worse than for all other industries within the United States.

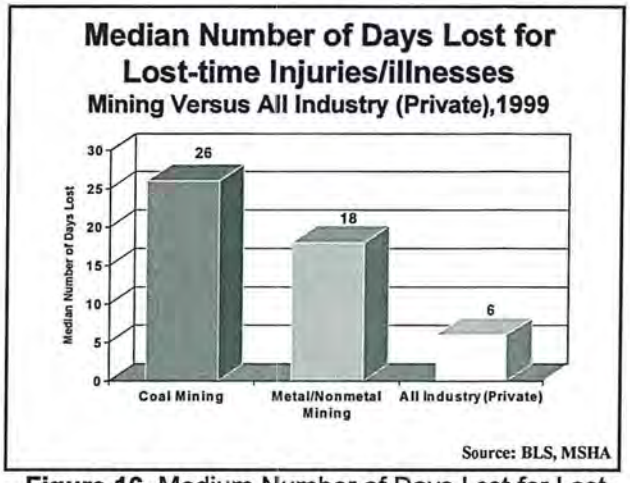

Figure 16. Medium Number of Days Lost for Lost-time Injuries/illnesses

Figure 17 looks back over the last 20 years at the number of lost-time injuries and illnesses, as well as the injury rates. Here again there is a leveling-off, particularly in the surface mining sector.

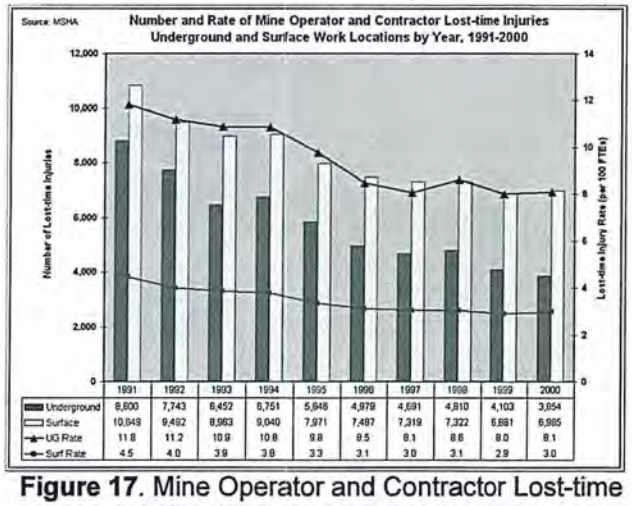

Figure 17. Mine Operator and Contractor Lost-time Injuries, Underground and Surface

Figure 18 examines causes of injuries in the underground mining industry. Materials handling, slips and falls, and falls of ground are the three principal causes.

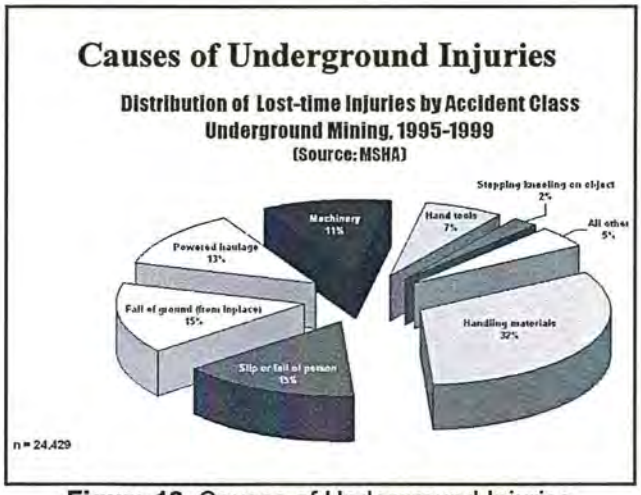

Figure 18. Causes of Underground Injuries

Figure 19 looks at causes of surface injuries. Here, materials handling and slips and falls of person dominate.

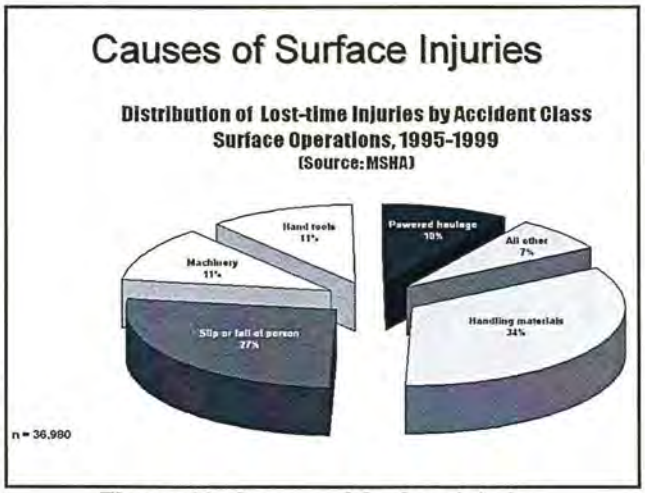

Figure 19. Causes of Surface Injuries

Figure 20 shows the number and rates of death for coal workers' pneumoconiosis (CWP) during 1968-99. Although there has been significant improvement, the problem still remains. We need to be ever vigilant in our effort to continue to stamp out CWP in the United States.

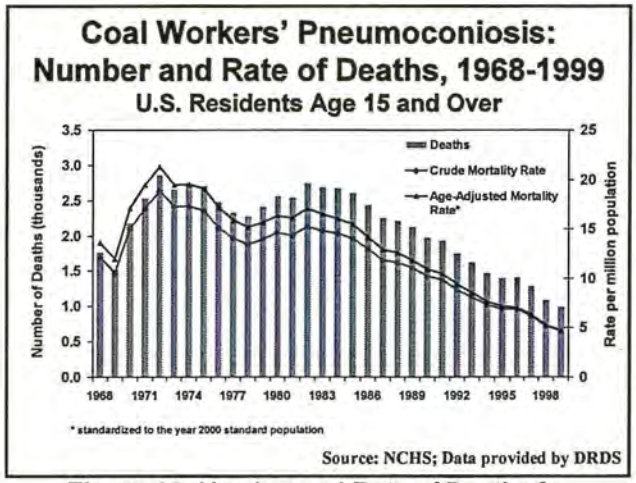

Figure 20. Number and Rate of Deaths for Pneumoconiosis

Figure 21 shows that 25% of people who have silicosis recorded as a cause of death on their death certificate work within the mining industry. The figure also shows that the coal, metal, and nonmetal sectors are fairly equal in silicosis-related deaths.

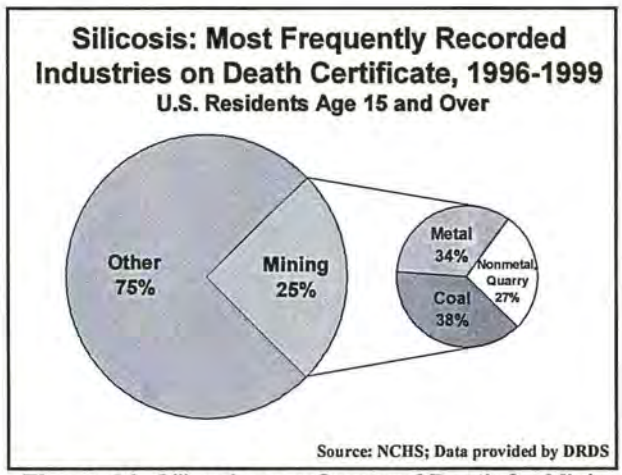

Figure 21. Silicosis as a Cause of Death for Mining Versus Other Industries

Figure 22 indicates that 30% of mining samples exceed the permissible exposure level for silica. This is based on MSHA inspector samples.

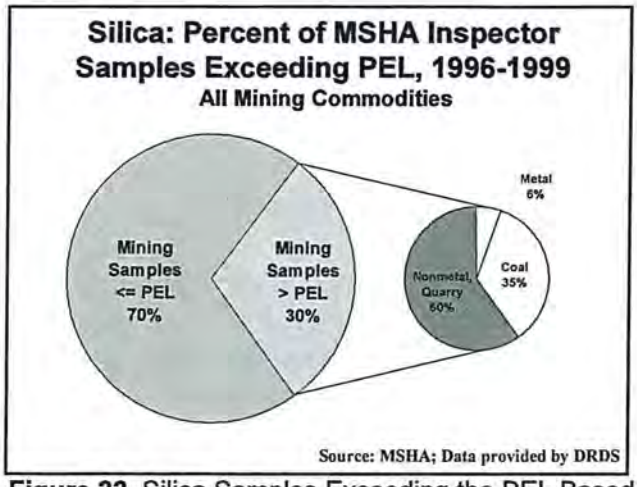

Figure 22. Silica Samples Exceeding the PEL Based on MSHA Inspector Results

Figure 23 contrasts the percentage of male hearing-impaired miners against age. The figure indicates that for miners approaching the latter years of their work life, there is a very good chance that they will suffer from a hearing impairment.

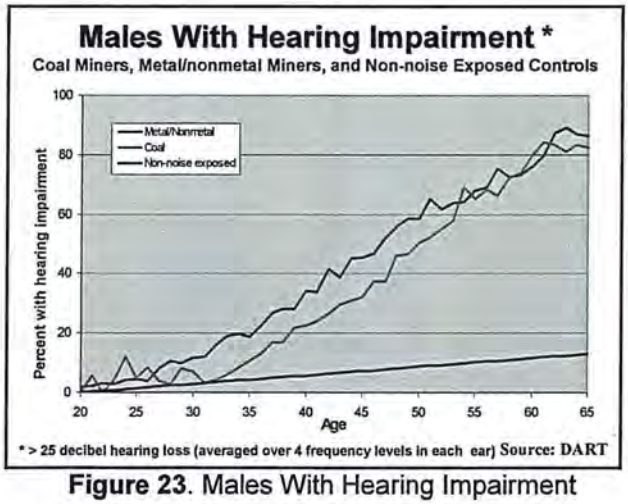

Figure 23. Males With Hearing Impairment

THE OPINION OF OTHERS AS TO FUTURE HEALTH AND SAFETY ISSUES

The First International Design for Extreme Environments Assembly met in Houston, Texas, in November 1991. It defined underground mining as one of the six extreme work environments, along with outer space, underwater, the Arctic, deserts, and mountains. The underground worksite was designated as a hazardous environment because it generally is in confined space and has poor visibility, the surrounding structure is unknown and unpredictable, and the atmosphere is dusty and potentially toxic or explosive.

RAND published a report in 2001 entitled "New Forces at Work in the Mining Industry: Industry Views of Critical Technologies." Of interest are the following two excerpts: "Mining equipment innovations not only litigate health and safety risk, but also address the need to create a more enjoyable, interesting, and productive work environment— critical to attract and retain highly qualified workers." "Despite the prospects of automation and other technology enhancements, people are becoming more critical to the success of the mining operation."

The National Research Council 2001 report on the evolution and revolutionary technologies for mining contain the following recommendations for research and development in health and safety: (1) technology to alert equipment operators of the existence and location of obstructions (such as equipment, berms, miners, etc.); (2) design specifications for automated operation in the mining environment that enhance robustness and reliability; (3) miner training programs to address special hazards that are created by the introduction of automated systems; (4) identification and elimination of workplace hazards introduced by new chemicals and bioagents; (5) identification of workplace risk factors that lead to muscular skeletal disorders (e.g., low back pain) and the design of equipment and training problems to eliminate them; (6) technology for assessing health and safety conditions in mine atmospheres; monitoring equipment that can distinguish the source of airborne pollutants (blasting, diesels, oxidation, cutting); an instrument that can reliably measure the amount of diesel particulate matter; instruments that can accurately measure real-time personal exposures, particularly exposures to airborne respirable coal mine dust; (7) determination of the health effects of mixed mode exposures in mine environments; (8) new materials and technologies to reduce noise in mining equipment and systems; (9) linking of computer-oriented monitoring of conditions in

mines with a safety information system and a rapid communication system to provide specific information in real time to each miner; and (10) virtual reality training modules for miners and mining equipment operators.

THE AUTHOR'S VIEW OF CHALLENGES AND OPPORTUNITIES FACING THE MINING INDUSTRY IN THE QUEST FOR IMPROVED WORKER SAFETY

The U.S. mining industry has come a long way in its health and safety performance. However, in the year 2001 there were 72 fatalities associated with mining, 160 permanent disabling injuries, 14,426 lost-time injuries, and 759 new cases of occupational illness. Clearly, we have a long way to go.

Based on the information presented above, the author presents the following concerns: (1) Increased production leads to increased dust and methane generations. Control technologies and strategies must keep pace. There is a need for real-time monitoring. (2) Increased mining depths and more complex geologic conditions require a more site-specific focus on ground stability designs. (3) The range and complexity of problems faced by the mining industry mandates that we approach these challenges in partnership. (4) For mining to get its due in terms of health and safety accomplishments and to get its fair share of the resources, we must ensure that the public is aware of the vital role that mining plays in the quality of everyday life. (5) The insidious problems that we face in mining (e.g., noise-induced hearing loss) need to get more focus. (6) Increased production and more difficult geologic conditions lead to a higher chance of the occurrence of mining disasters. (7) The rapidly changing demographics of the mining workforce is apparent by the influx of younger and inexperienced miners. There is a need to capture the experience and expertise of older workers. The growing prevalence of English as a second language requires that we focus on training—*training that works*.

CONCLUSION

If we are to continue to make progress in the area of health, safety, and mine productivity, it is important that all of us—Government, industry, labor, and academia—come together and work together in partnership. The problems that we face are too difficult for us not to use the full weight and talent of all involved. In those efforts, we must never forget one thing: that our efforts must be about the health and safety of the mine workers.

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"HOW I SEE IT"

Joseph N. Ayers

Lafarge North America, Inc.

When I was asked to speak at this conference, my first thought was, "what can I tell this group of distinguished Safety and Health professionals and scholars that they don't already know?" After some deep thought and soul searching, I came to the conclusion that there is probably nothing that I could tell you that is NEW and GROUND-BREAKING. However, I can elaborate on the theme of this conference, "Health and Safety's Role in a Changing World" and how it relates to my experiences as a Safety and Health professional.

I would like to concentrate on several key items and how they have affected the effectiveness of the Safety and Health programs that I have been involved with.

The first of these key issues is staffing. Staffing of Safety and Health programs within mining companies has taken a serious turn in the past 10 years. There were times in the past when companies not only stressed the fact that the safety of their workforce was their top priority, but they also staffed their programs appropriately. For example, my current position has gone from a staff of 6 to 1 in just 5 years. There was a Safety Manager, a Loss Control Manager, an Environmental Manager and each had their own administrative assistant. Now my current position description, if spelled out would read: Manager of Health, Safety, Environmental, DOT, and Risk Management. I currently have no administrative support, and I know many others out there who are in the same boat. Also, with the trend of larger mining companies buying up downstream companies such as Ready-Mixed Concrete and Asphalt, these managers are also in charge of OSHA, EPA and DOT issues as well. This trend causes field professionals to be multi-tasking wizards that prioritize everything—and anything that doesn't fit into these priorities gets put on the back burner and is sometimes left undone. You become a "Jack of all trades---Master of NONE".

The next key issue is the result of the technical generation. If you are trying to hire new employees to replace those that are retiring, you have already seen this phenomenon. Our children have been exposed to computers, video games and technology since before kindergarten. Every 5 minutes on the radio you can hear: "Tired of your job, the ole' 9-5 got you down? Why not train in the exciting new computer fields? Right now MicroSoft DBA's are making in excess of 60K/year." No one in their right mind would want to come to work in a dirty old rock or coal mine when they can sit at a computer in a nice air conditioned office and make 10 times the money. I personally believe that in most parts of the country, we as members of the mining and construction industry have not done enough to market our industry to our youth in schools; many never even know that there are mining jobs available in their areas. They also don't know how far our industry has progressed with technology. This is a great selling point for

our youth to come over and bring their natural abilities to benefit our industry.

Well, so far I've been up on my high horse a little and that usually leads to a nice fall, but I have one last item that is a direct result of the last 2 items.

Our aging work force. If you aren't having issues relating to an aging workforce, then you aren't mining. Just look at the gentlemen who were trapped in the mine in Somerset last month. Out of nine miners, only one of them was under 40, and he was 31. The average age of those miners was 48 years old. This trend is evident everywhere. We are experiencing many muscle strains and overall health related issues as a direct result of having men trying to accomplish the same things that we expected of them when they were in their twenties. The health issues from years of dust and noise exposures prior to corporate responsibility and accountability are also weighing heavily on employees and employers now. Many pre-existing conditions become worse with age, and we all know that they create misery for all involved.

Finally, I would like to stress that I am in no way complaining about these things. They are important issues that aren't going away any time soon. We as Safety and Health professionals need to be diligent in our efforts to protect these individuals so that they can retire healthy and enjoy the fruits of their labors. In the words of Charlie Moorecraft, "everyone deserves a future."

LUNCHEON SESSION:

PRESENTATION OF THE MINING HEALTH, SAFETY & RESEARCH PROFESSIONAL AWARD

PROFESSIONAL AWARD FOR MINING HEALTH, SAFETY & RESEARCH

JOE LAMONICA began his career in 1963 with the U.S. Departments of Labor and Interior, and he worked extensively for the Bureau of Mines. During that time he fulfilled a number of responsibilities while working in the Respirator Approval Lab and Respirable Dust Group. Later he served as Chief of both the Noise Group and the Health Division for Coal Mine Safety and Health.

From 1980 to 1986, Joe served as the Administrator for Coal Mine Safety and Health, Senior Executive Service, under the U.S. Department of Labor in Washington, D.C. Following his service in the U.S. Department of Labor, Joe moved on to Lexington, Kentucky, where he became the Corporate Director of Health, Safety and Risk Engineering for the Island Creek Coal Company. From 1994 to 1999, Joe served as the Vice President of Health, Safety & Training for the Bituminous Coal Operator's Association (BCOA) in Washington, D.C., and since that time he has continued working as a consultant for the BCOA.

Throughout his career, Joe has been a key figure throughout numerous Mining Health, Safety and Research Institutes. Starting with the first annual institute in 1970, Joe served as a participant, speaker and co-chairman, and he has served as a member of various government Advisory and Executive Committees. His dedication to the Institute has earned him respect from peers and fellow researchers. In recognition of his outstanding career accomplishments and his extensive contributions to the field of mine safety, the 33rd Annual Institute on Mining Health, Safety and Research is pleased to present to Joe Lamonica the **Professional Award for Mining Health, Safety and Research**.

TECHNICAL SESSION I:

HEALTH AND SAFETY ISSUES

Session Chair

Jeffrey Kohler
Research Director
National Institute for Occupational Safety and Health (NIOSH)
Pittsburgh Research Center

INITIATING AN ERGONOMICS PROCESS AT A SURFACE COAL MINE

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U. S. Department of Energy

BACKGROUND

Musculoskeletal injuries have been identified as a significant and costly problem for the mining industry. The National Institute for Occupational Safety and Health (NIOSH) conducted the National Occupational Health Survey of Mining (NOHSM) to characterize health related agents found at U.S. mines (NIOSH 1996). An important part of this survey was to identify potential exposures to musculoskeletal overload conditions. A total of 491 mines (60 coal mines and 431 metal or nonmetal mines) were surveyed. The percentage of miners potentially exposed to each of the 12 musculoskeletal overload conditions defined by NOHSM was calculated for coal mining and then for metal and nonmetal mining (Zhuang and Groce, 1995). The average percentage, over all twelve conditions, for coal mining (26.2%) was significantly greater than that in metal and non-metal mining (17.2%). The three most common musculoskeletal overload conditions were (1) bending forward, bending to the side, hyper extending, or twisting the neck or back; (2) unsupported, abducted elbows, forearms resting on sharp edges, tossing motions at extremes of range of motion, or working with hands above shoulders; (3) lifting greater than 50 pounds, unaided. At least 35% of mine workers (over 40% of coal mine workers) were potentially exposed to each of these three conditions. An analysis of NOHSM results for 24 commodities associated with metal and nonmetal mining concluded that the potential exposure to ergonomic hazards for those miners was high compared to non-mining occupations (Winn et al, 1996). Exposure of mine workers to musculoskeletal overload conditions clearly plays an important role in the development of musculoskeletal injuries at coal, metal, and nonmetal mines.

In 1998, the Mine Safety and Health Administration (MSHA) submitted a formal request to develop a cooperative project with NIOSH to investigate musculoskeletal disorders in the mining industry. MSHA representatives believed that the available injury data was not accurately representing the extent of musculoskeletal disorders in the mining workforce. NIOSH researchers took this as an

opportunity to consider a comprehensive systems approach for examining ergonomics issues in mining. A research plan with three primary objectives was developed: assess musculoskeletal disorder risk factor exposures in mining environments; identify means to reduce hazard exposures through engineering, administrative, and work practice controls; and evaluate the effectiveness of ergonomics interventions.

To accomplish the second and third objectives, the NIOSH team decided that a formal ergonomics process needed to be installed at a cooperating mine site to identify and test the effectiveness of possible interventions. This paper discusses the steps taken to implement such a process at the Bridger Coal Company in Rock Springs, Wyoming.

ERGONOMICS PROGRAMS

There is evidence that ergonomics interventions can be effective in lowering musculoskeletal discomfort and injuries for workers in a variety of industry settings. A study of four private sector ergonomics programs (GAO/HEHS, 1997), found that the number of reported injuries and illnesses per 100 full time workers in 1996 were from 2.4 to 6.1 less than in 1993, the year prior to full implementation of the programs. Ergonomic improvements may also result in increased productivity and higher product quality (Cohen et al, 1997).

Ergonomics programs provide a way for workers and employers to identify jobs that are physically demanding or causing problems, develop ideas to reduce the risk of the job, and track interventions to ensure that they are effective. The structure and implementation of an ergonomics program varies based on the makeup and goals of an organization. In general, NIOSH recommends a seven-step approach for developing an effective ergonomics program to address musculoskeletal injury concerns (Cohen et al, 1997):

1. Look for signs of potential musculoskeletal problems in the workplace, such as frequent worker reports of aches and pains or job tasks that require repetitive, forceful exertions.

2. Obtain management commitment in addressing possible problems and encourage worker involvement in problem-solving activities.

3. Provide training to expand the ability of management and workers to evaluate potential musculoskeletal problems. In particular, enhance their ability to recognize musculoskeletal disorder risk factors.

Risk factors are characteristics of the work setting that could contribute to the occurrence of an injury or increase the chance of a musculoskeletal disorder. The potential for a risk factor to contribute to an injury is usually affected by the duration of the worker's exposure. Common musculoskeletal disorder risk factors include:

- Poor posture
- Forceful gripping
- Heavy or frequent lifting
- Highly repetitive work
- Hand/arm vibration
- Contact or impact stress
- Bouncing or jarring

4. Gather data to identify jobs or conditions that are causing problems, using sources such as injury reports, medical records, and job analyses.

5. Identify new approaches for performing tasks that pose a risk of musculoskeletal injury and evaluate these approaches once they have been instituted to see if they have reduced or eliminated the problem.

6. Establish health care management to emphasize the importance of early detection and treatment of musculoskeletal disorders.

7. When new work processes are developed, take steps to minimize musculoskeletal risk factors.

This approach is consistent with the guidelines for meatpacking plants published by the Occupational Safety and Health Administration (OSHA, 1993). These guidelines have been used by general industry as the basis for many ergonomics programs.

Whatever forms an ergonomics program may take; there are several characteristics common to all programs that help to indicate their potential for success (GAO/HEHS, 1997):

- Strong management commitment to the goals and budgetary needs of the program
- The availability of training in team building and ergonomics
- Formation of diverse teams that are of a manageable size
- Encouraging worker input to help define the overall program and team objectives
- Frequent communication within the organization on the program's objectives, progress, and accomplishments

BUILDING AN ERGONOMICS PROGRAM

To evaluate the effectiveness of ergonomic interventions within a mining organization, NIOSH needed to find a long-term partner to accept assistance with installing an ergonomics process and monitoring the effectiveness of the introduced interventions.

Finding a Cooperator and Obtaining Management Commitment

With the assistance of a member of the National Safety Council Mining Division, NIOSH contacted several mines and asked them to participate. The safety director at Bridger Coal, situated outside Rock Springs, Wyoming, was familiar with the problems associated with cumulative trauma and musculoskeletal injuries and felt that an ergonomics program could have a positive impact. He arranged for NIOSH to make a presentation to all the mine's management on basic ergonomics principles, the ergonomics approaches used by other companies, and risk factor identification.

The next step was to ensure commitment at the corporate level. The Bridger Coal safety manager arranged a meeting of safety personnel from within PacifiCorp's Generation Business Unit. NIOSH again presented the ergonomics approaches used successfully at other large corporations, as well as the expected benefits for Bridger Coal. The hope was that Bridger Coal would be the model for PacifiCorp's Generation Business Unit (and possibly for other mines across the nation). The outcome of this meeting was corporate approval to install an ergonomics process at Bridger Coal.

Forming and Training an Ergonomics Committee

It is critical that the design of an ergonomics process allows both management *and* employees to participate. After reviewing approaches taken by other businesses, the mine management decided that forming an ergonomics committee would be the best way to establish the program at Bridger Coal. A new committee, separate from the mine's existing safety committee, would allow the company to more easily commit resources to changing its work environment and work philosophy.

The committee included representatives from labor and management, as well as the company's medical department. Committee members were asked to make sure they would have the time to devote to their new responsibilities. The mission they were given was simple and direct:

Identify, evaluate and correct working conditions that need ergonomic improvement.

With the committee formed, the members received a series of formal training sessions from NIOSH covering the following topics:

- An explanation of ergonomic programs, including why they are important to workplace safety
- Background information on successful programs at other companies (Ford, General Electric and American Electric Power)
- Basic principles of ergonomics
- Identification of ergonomic risk factors (poor postures, repetition, force, etc.)
- Selection of criteria for prioritizing work site tasks to evaluate
- Establishment of criteria for selecting interventions (timeliness, ease of implementation, cost/benefit ratio, etc.)

Putting Together a Day-to-Day Process

The ergonomics committee developed a day-to-day process it would use to reduce employee exposure to ergonomic risk factors. Detailed below and diagramed in Figure 1 is the general process that the committee has implemented and is using to address issues that are not part of the NIOSH evaluation project:

1. An employee reports a concern to the committee. One way he or she can do this is by using a 4″×6″ Risk Factor Report Card, readily available to everyone (Figure 2).

(continued on pg. 44)

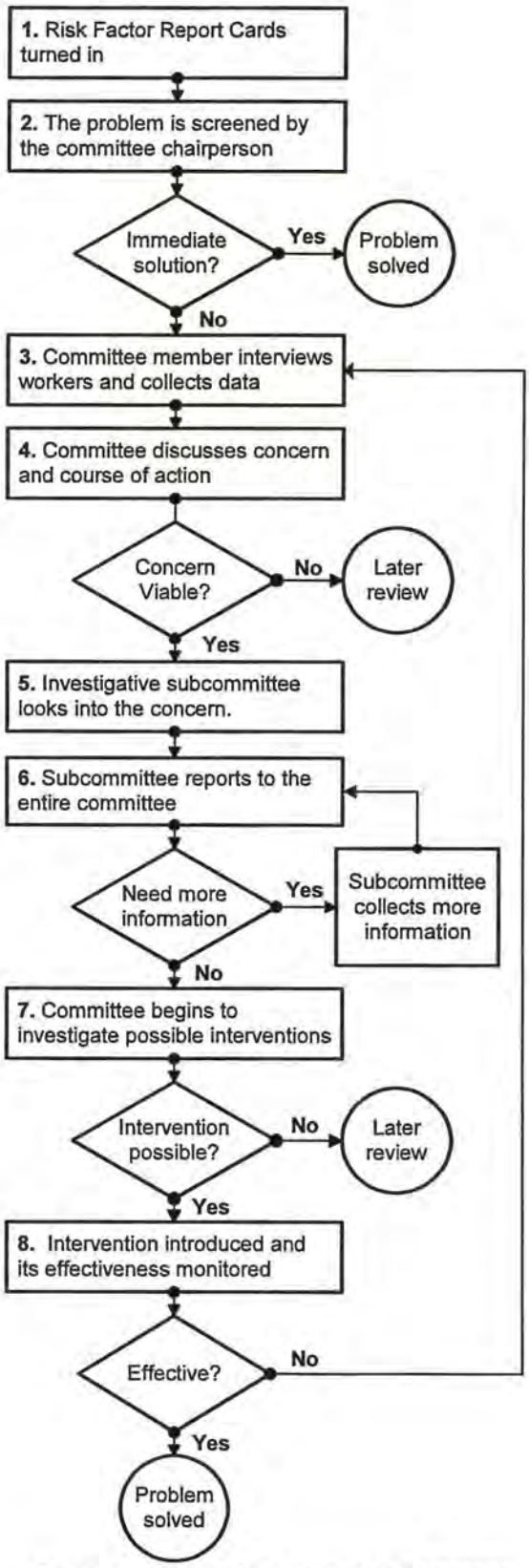

Figure 1. Bridger Coal Ergonomic Process Flowchart.

1. Comments/suggestions:

Risk Factor Report Card

2. Check all risk factors that apply:

9 Poor Posture
9 Repetitive Work
9 Vibrating Tools
9 Forceful Gripping
9 Heavy Lifting/Carrying
9 Bouncing/Jarring

Other risk factors: _____

4. Name: _____

5. Work area: _____

3. Mark areas affected with an **X**

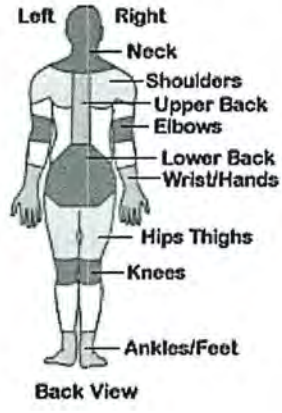

Figure 2. Risk Factor Report Card.

Task: _____ Work Area: _____ Date: __/__/__ Reference No.: _____

Risk Factor	Measurements & Body Parts Affected	Reasons for the Risk Factor
1. Poor Posture 	How many hours per day: _____ How many days per week: _____	
2. Heavy or Frequent Lifting 	Typical weight handled: _____ How many times per day: _____	

Figure 3. Portion of a Task Observation Worksheet.

2. The committee chairperson screens the reports to determine if the concern is truly an ergonomics issue and whether or not it can be handled immediately.

3. If more information is needed a committee member is assigned to talk with affected workers about their concerns using data collection tools such as the Task Observation Worksheet (Figure 3).

4. The committee discusses the concern. If it is something that currently has no practical solution, or if it is beyond the abilities of the committee to deal with, the issue is filed for later review and the employee submitting the concern is briefed.

5. An investigative subcommittee is then formed with both committee members *and* employees to assess the concern.

6. When the subcommittee has finished its analysis of the concern, a report is given to the entire committee. If necessary, the committee may decide to collect more information to further define the issue.

7. When the committee feels that the concern has been well defined, it investigates possible interventions. An intervention is chosen based on a number of factors, such as an expected reduction in injuries, a reduction in risk factor exposure, its ease of implementation, and expected productivity improvement. If no intervention is possible the issue is filed for later review and the employee submitting the concern is briefed.

8. After an intervention is introduced, its effectiveness is monitored. A committee member interviews affected workers to see if things are better and if any unexpected problems were created. If it fails to alleviate the concern or causes new ones a new intervention is tried and monitored.

How the Workforce Is Kept Involved

Keeping the workforce and union involved with the ergonomics process was considered crucial to its success. This was accomplished in several ways:

Ergonomics Awareness Training was provided by NIOSH to small groups of employees over a period of several days. Separate training was given to office and field workers. Eventually, the entire workforce attended one-hour sessions covering the following topics:

- What is the Bridger Coal Ergonomics Committee and what is its mission?
- What is ergonomics?
- What are the differences between acute and cumulative injuries?
- What are the signs and symptoms of cumulative injuries?
- The importance of a proactive approach to preventing cumulative injuries
- Basic anatomy of the back and wrist
- Cumulative injury risk factors such as poor posture and repetitive work
- How to identify musculoskeletal disorder risk factors
- Techniques for preventing cumulative injuries, such as engineering and work practice controls, personal protective equipment, and training

The training concluded with a job improvement workshop where the employees practiced identifying risk factors associated with various jobs.

Risk Factor Report Cards are readily available to all employees to submit to the committee and serve to remind workers of the importance of being aware of risk factors.

Posters are frequently displayed and updated around the mine site highlighting progress on various issues. These also serve to ensure employees that their concerns are being addressed.

Investigative Subcommittees are formed when a risk factor report card is submitted and the concern has no immediate solution. Affected employees are given the opportunity to participate on subcommittees assigned to gather information on their concerns. This insures the subcommittees will have input from workers actually performing a job being studied.

STATUS OF THE BRIDGER COAL ERGONOMICS PROCESS

The process at Bridger Coal has been in operation for approximately one year. It will take several more years for it to evolve and be fully accepted. A plan on how to assess its impact will be developed jointly with NIOSH and Bridger Coal management. However, employees have turned in over forty Risk Factor Report Cards and the ergonomics committee is addressing over a dozen separate issues. Examples of ongoing projects include:

- Handle design on 20 lb. sledge hammers
- Jolting and jarring during ripping tasks with certain dozers
- Manual handling of dragline power cables
- Heavy manual lifting performed by mine service operators while unloading trucks
- Control layout on drilling machines
- Impact resistant gloves for mechanics

There are several projects where interventions have already been introduced by the committee and are being evaluated:

Water Truck Pump Switches - Drivers reported that they had to constantly lean over in their cabs and hold their arm in an elevated, extended position to operate the pump switch. The problem was worse in colder weather, when the pumps had to be turned on and off continuously during spot watering to avoid icing up the haul roads. Moving the pump switch to a location near the gearshift tower solved the problem with minimal cost (Figure 4). The new position eliminates constant reaching between the gearshift and the pump switch, reducing the risk

Figure 4. The new position of the pump on/off switch near the gearshift lever allows the operators to keep their arms closer to a neutral posture.

of operator error as well as cutting down on awkward posture and repetitive motions.

Welder Hoods - Workers reported that the weight of the welder hoods might be causing neck and back pain. After searching for quite some time, the committee found a new style of hood that is significantly lighter and offers the same protection. Initial feedback from the workers has been positive. If continued testing shows the new hood reduces neck and back pain, it will become the standard for the mine.

Rubber Tired Loading Machine Foot Pedal Design - Operators indicated that they were experiencing hip, knee and ankle pain while operating the foot pedal on a certain type of loading machine. After studying the problem, the angle of the pedal with the floor was lowered. The operators have reacted very positively to this change, reporting that their hip, knee and ankle pain has been significantly reduced or eliminated.

The Bridger Coal ergonomics committee is carrying out these interventions, with NIOSH serving in a consulting role only. However, two concerns indicated on the report cards have resulted in NIOSH-led efforts for interventions. These interventions will be introduced in a controlled manner, with extensive baseline data collected before the intervention is introduced

and additional data collected for several years after the introduction. This approach will allow the NIOSH researchers to better understand and report on both the effectiveness of the intervention and its method of introduction. The NIOSH intervention projects include:

Dragline Workstation Design - Report cards and the mine's injury records indicated that a large percentage of dragline operators (41%) were regularly experiencing shoulder pain. The job requires high levels of repetitive wrist, elbow and shoulder motions to manipulate the dragline's two joystick controls (Figure 5).

Figure 5. Dragline operator using joystick controls.

Powder person tasks - Information received from supervisors and workers indicate that the powder person crew performs manually intensive work at the mine in rather extreme weather conditions. These include tying the shots, shoveling, taping holes (Figure 6), and awkward postures while loading holes. Some of these tasks will be examined to assess frequency and duration of exposure to a variety to risk factors. Alternatives will be investigated that fit within the context of engineering design, work practices, and personal protective equipment.

Figure 6. Pulling tape from the blast hole.

SUMMARY

An ergonomics process provides a structured framework for workers and employers to identify jobs that could lead to musculoskeletal disorders and to develop solutions that make the work less physically demanding. Increasing their knowledge of ergonomics principles and the application of engineering, administrative, and work practice controls can accomplish this.

Bridger Coal Company, working with its local union and NIOSH, has initiated an ergonomics process at its Rock Springs, Wyoming surface operation. The process is just over one year old and already over one dozen problems have been identified by the workforce and are being addressed by the ergonomics committee.

Over the next several years, NIOSH will continue to monitor the process implemented at Bridger Coal and will develop and evaluate two interventions at the mine. The ergonomics process put in place will facilitate the NIOSH intervention effectiveness evaluation, as well as providing Bridger Coal with a long term means to reduce their worker's exposures to health and safety risk factors.

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SUMMARY OF COAL NOISE CONTROL WORK AND INFORMATION NECESSARY TO OBTAIN A "P-CODE" WHEN ALL FEASIBLE OPTIONS HAVE BEEN EXHAUSTED

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BACKGROUND

The Mine Safety and Health Administration (MSHA) promulgated revised noise rules on September 13, 1999 which became effective on September 13, 2000. During the one year implementation time period, work was undertaken to educate the mining community on the new requirements and provide assistance to the mine operators to gain compliance. It was generally accepted that the coal community had the greatest challenge with meeting the new requirements.

The new rule required the use of feasible engineering and administrative controls to reduce miners' exposures to noise levels that were in excess of the permissible exposure limit (PEL). The PEL of 90 dBA was not changed by the revised rule. The 90 dBA level was established in the previous MSHA rules which were promulgated in the early 70's for both coal and metal/nonmetal mines. The new rule did provide for an Action Level (AL) of 85 dBA. Miners determined to be exposed above the AL are required to be enrolled in a hearing conservation program that provides training, access to audiometric examinations, and selection of personal hearing protectors.

NOISE CONTROL WORK

In late summer of 2000, it was realized that there were certain areas in coal mining that were having difficulty in obtaining compliance with the PEL. Coal Mine Safety and Health (CMS&H) determined that there were six major areas that were in need of additional compliance assistance. Those major areas were: 1) Continuous Mining Machine operators, 2) Roof Bolting Machine operators, 3) Longwall occupations, 4) Dragline Machine operators/Air Arc Cutting, 5) Shaft and Slope Sinking occupations and 6) Preparation Plant occupations. Each of these six areas was assigned a team of trained personnel that were instructed to evaluate the particular problems associated with a given area and to work with mine operators and manufacturers to develop and apply noise control technology and techniques.

The results of these six teams have generally been very positive. They have focused attention on specific problem areas in order that resources from operators, manufacturers and government are directed toward those areas that are likely to have the greatest impact on reducing noise exposures. The following is a summary of the actions that each team found that produced a positive impact on the reduction of the miner's overall noise exposure.

Continuous Miner Team

Machine Mounted Scrubbers
1) Sleeve and bolt on attenuators
2) Silenced fan housing
3) Crossover duct noise kit
4) Fan blade clearance

Conveyor Chain
1) Proper tension
2) Maintenance (replace worn/broken parts)

Barriers
1) Barrier between conveyor and operator

Operator Position
1) Position with remote control

Auxiliary Fan
1) Silencers
2) Enclose fans
3) Two-stage fan
4) Tubing maintenance

Roof Bolter Team

Wet Drilling
1) Approximately 12 dB reduction

Blower Muffler
1) Maintenance
2) Water box, reduction varied 1-7 dB

Appropriate Drill Tools
1) Use most dense steel
2) Use one piece steel when possible
3) Two foot starter steel length
4) Use sharp bits

Maintenance
1) Eliminate drill pot whistle
2) Replace worn/warped/drifting pot
3) Repair holes in vacuum hoses

Training
1) Maintain hole alignment
2) Operator position
3) Elimination of "bad" habits

Equipment Improvements
1) Feedback drilling system
2) Hydraulic driven blower

General - Underground Mantrips
1) Dampen seat area
2) Enclose seat area
3) Muffler - diesel powered

Longwall Team

Administrative Control
1) Rotation of miners
2) Operating position with remote control

Engineering Control
1) Enclosures for miners
2) Replace air cooled motors
3) Enclose or wrap motors

Maintenance
1) Maintain pan line chain

Dragline/Air Arc Cutting Team

Dragline
1) Barriers for MG sets
2) Redirect fan exhaust
3) Rubber mats on floor
4) Air conditioner to replace house fans
5) Bolt-on silencers for motor fans

Air-Arc Cutting

1) Selection of alternative products or cutting system (use of alternative cutting may reduce noise levels to below 90 dB)

Shaft and Slope Sinking Team

Drilling

1) Muffler
2) Smallest diameter drill steel
3) Collar holes before applying full pressure
4) Regulate air pressure to manufacturer specifications

Mucking

1) Maintenance
2) Alternative powered mockers (diesels, hydraulic)
3) Alternative loading (clam-shell)

Surface Installations

1) Site planning
2) Sound deadening enclosures
3) Barriers
4) Inlet and exhaust silencers on fans

Ambient Noise

1) Flexible connections on ventilation fan duct
2) Install fan tubing with insulating hangers
3) Different type of fan tubing and blades

Preparation Plant Team

Barriers

1) Control booths/rooms
2) Vinyl curtains

Design

1) Relocation of fan exhaust
2) Enclosing and directing exhaust to outside

More detailed reports covering the work of these teams can be obtained from MSHA's web page under the "Special Initiatives - Noise Rule" section. The Agency is preparing a revision of the Noise Control Manual, also accessible through this same web site, which incorporates many of the team findings.

P-CODE PROCEDURES

The second area I would like to discuss is the process of obtaining a "P-Code." A"P-Code" is an administrative procedure for handling areas on a mine site where miners are exposed to excessive noise levels that result when the use of all feasible engineering/administrative controls fail to reduce the noise exposure to at or below the PEL. In such instances, the mine operator must implement and maintain those controls that lower the noise exposure as low as possible and then provide personal hearing protection suitable for work in the environment and the agreement of the mine operator to implement any new control measures that are found to reduce the noise exposure of miners. The listing of these control measures, both engineering and administrative, the hearing protection requirements and the inclusion of all affected miners in a hearing conservation program are all combined to form the basis of a "P-Code" for this area. Adherence to the P-Code" provisions will result in no further enforcement action for this specific location.

There are several actions that must take place before a "P-Code" will be issued. A "P-Code" can be initiated by a request of the mine operator or as the result of a citation issued for overexposure to noise. The operator must have attempted to reduce the noise exposure of the miner in the affected area. If the levels still exceed the PEL then a request for assistance from MSHA and/or the involvement of a noise control consultant should be undertaken. Any feasible controls identified must be implemented and a new evaluation of exposures made. If the noise exposures continue to exceed the PEL, the mine operator should notify the MSHA District Manager and request that MSHA consider the specific operation for a "P-Code." The operator's request should provide the history of exposure levels, the specific controls

implemented, a discussion of controls not utilized with data/information as to why they were determined as not feasible for this specific situation and a description of the tasks and operation related to the miners whose exposure exceeds the PEL.

MSHA will conduct a thorough review of the request, including a detailed evaluation of the subject area/equipment at the mine site. The following is a list of those actions that the district is expected to complete when evaluating a "P-Code" request.

- Provide a brief narrative describing the operation and working conditions that resulted in the overexposure
- Provide a sketch of the overall area
- If the noise overexposure is linked to discrete piece(s) of equipment, provide the following information for each piece of equipment
    - Manufacturer's name
    - Manufacturer's address
    - Manufacturer's telephone
    - Type and model of machine
    - Year Manufactured
    - Serial Number

- If a citation has been issued, provide a copy of the following information
    - Citation
    - Citation Extensions
    - Inspector's field notes

- If Technical Support has been involved, attach a copy of the report/recommendations
- If a MSHA Noise Source Identification Team has been involved, attach a copy of the report
- Include a description and effectiveness of the controls utilized
- Include a description of controls considered, but not used
    - reasons why the controls were not used
    - narrative explaining the infeasibility of reasonable administrative controls

- If a consultant was used include the following:
    - Test data and results
    - Recommendations
    - Conclusions

- Determine if the recommendations made by the inspector or specialist were implemented
- Assess whether additional training on noise is needed
- Noise Data
    - Q-300 noise dosimeter survey
    - time motion study
    - sound level readings
    - octave band analysis

Once the district has completed the necessary field evaluation, they must determine if there are any feasible engineering or administrative controls available that the mine operator has not implemented. These controls will be presented to the mine operator for implementation. Failure to implement feasible engineering or administrative controls may result in a citation for exceeding the PEL. If after implementation of all feasible controls, the PEL is still exceeded, then the District Manager will prepare a request for the Administrator to approve a "P-Code" which presents the following information:

- Mine ID
- Mine Name
- Company Name
- Location that "P-Code" covers
    - specific piece of equipment (Dozer #386-1992 D-8)
    - specific location (i.e., 10 ft area extending around crusher located on 7th floor raw coal feed belt.
    - Entity number if applicable (MMU 001-0)

- Occupation codes of miners affected (046 & 047)
- List controls implemented or currently in place
- Specify the administrative controls used - attach a copy of the operator's control program.

- Specify the hearing conservation program details
  - when affected miners will receive training on this hazard
  - proper use of PHP
  - controls that must be maintained
  - when and where audiometric test are available
  - what PHP is available for the miners to select from

- Specify when and where affected miners are required to use PHP.
- Attach a copy of all evaluation data

Once the district request is received, a team consisting of a staff person from the applicable Health Division, representative(s) from the district and MSHA Technical Support will evaluate the information and make a recommendation to the Administrator. The Administrator is the only person who may approve a "P-Code," The approved "P-Code" will be transmitted to the operator by the District Manager.

SILICA DUST SOURCES IN UNDERGROUND LIMESTONE MINES

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ABSTRACT

NIOSH's Pittsburgh Research Laboratory is currently involved in research to identify silica dust sources and generation in underground metal/nonmetal mines. The ultimate goal of this research is to develop control technologies to reduce worker exposure to respirable silica dust. Baseline dust surveys were conducted in underground limestone mines in Pennsylvania to investigate primary silica dust sources, generation levels, and controls being used. Three primary sources currently under investigation include dust generated by crushing facilities, face shots, and haul trucks. A summary of sampling procedures, resulting data, and methods being investigated to reduce silica dust will be discussed.

INTRODUCTION

Chronic overexposure to respirable crystalline silica may lead to silicosis, which creates irreversible and progressive deterioration once the dust has been deposited in the lung tissue. Historically, mining has been a one of the highest risk industries for worker exposure to crystalline silica dust. Through the 1980's and into the 1990's, United States Bureau of Mines (USBM) research program addressing silica dust sources and worker exposure had mainly focused on surface and underground coal mining and surface processing operations for the nonmetal mining industry. Numerous studies were conducted which have lead to the development of improved control technologies for reducing silica exposure in high-risk occupations in these operations. However, studies addressing silica dust occurrence and exposure in underground metal/nonmetal mines had not been a high priority in the USBM dust control research program. When the health and safety research functions of the USBM were transferred into the National Institute for Occupational Safety and Health (NIOSH), a strategic planning effort was conducted to identify areas of need that warranted new or continued research efforts. To identify high risk occupations in underground metal/nonmetal mines, the MSHA compliance sampling results were evaluated for contaminant code 523, which is defined as a full shift sample with a total mass gain on the filter equal to or greater than 0.1 mg and a crystalline quartz respirable fraction greater than or equal to 1% determined by X-ray diffraction (XRD) following the NIOSH 7500 Analytical Method (NIOSH, 1994b). For the period from 1993 to 1998, the data shows that the average percent of these samples exceeding the Threshold Limit Value ® (TLV) ® was 15%, with considerably higher overexposures for high-risk occupations (MSHA, 1999). Consequently, a research project was initiated to address worker exposure and silica dust control for the more than 10,000 miners currently employed in over 300

underground metal/nonmetal mines (MSHA, 2000).

MSHA classifies the metal/nonmetal division in four main categories; sand and gravel, metallic minerals, nonmetallic minerals, and stone. A major component of the underground metal/nonmetal research program is the investigation of silica dust in the underground crushed and broken limestone industry, which is one of the main commodities in the stone category. Figure 1 is the frequency of MSHA dust sampling (MSHA, 2001), as a percent of total samples taken, for the major commodities in the underground stone industry for the years 1996 to 2000. The sampling data shows that 43% of the sampling occurs in the crushed and broken limestone commodity.

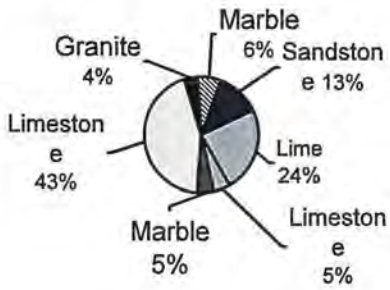

Figure 1. MSHA dust sampling as percentage of total samples taken.

Currently, there are approximately 110 underground crushed and broken limestone mines in the US, representing the largest segment of the underground stone industry. Depending on the geology, some limestones may have a higher sand component, while others have a higher calcite component. Studies on the sources of silica dust (Ramani, et. al., 1987) have shown a strong correlation between the airborne concentration and percent silica in the host rock. Historically, higher levels of silica have been observed in mines located in the Northeastern and South Central MSHA districts. The Northeastern and South Central Districts have 19 and 18 mines respectively, and account for 35% and 25% of the total samples taken (MSHA, 2001).

Due to demand, the number of underground crushed and broken limestone mines are increasing on a yearly basis as quarry operators exhaust their surface reserves and begin underground operations. Room-and-pillar mining methods are utilized, typically using pillars with square dimensions ranging between 10.6 to18.3 m (35 to 60 ft). The entries are considered large mine openings with entries widths ranging from 9.1 to 18.3 (30 to 60 ft) and entry heights on development ranging from 4.9 to 12.1 m (16 to 40 ft). After benching, entries can be over 18.3 m (60 ft) high. Many of the dust sources, which are not problematic in a surface operation, have now become a issue in the underground environment. Many of these sources may increase the level of respirable silica dust at generation points as well as in the overall mine atmosphere since these large openings can be difficult to ventilate. Occupations with the highest risk of overexposure include truck drivers, crusher operators, front-end loader operators, and rotary drill operators. On average, 20 to 25% of the samples from these occupations exceed the TLV ®(MSHA, 2001).

The NIOSH research program is addressing these silica issues by quantifying dust levels at major sources in the underground crushed and broken limestone industry. Baseline sampling surveys were conducted for three different sources, 1) dust generated by an underground dump/crusher facility; 2) dust generated by face shots; and 3) dust within a truck drivers cab generated by loading, dumping and tramming activities. The objective of these studies was to determine silica dust levels generated by these operations and assess the controls in use. The ultimate goal of this research is to develop or modify dust control technologies to reduce worker exposure to respirable silica dust.

SAMPLING INSTRUMENTS USED IN SURVEY

Two types of dust sampling instruments were used in these studies. The first type and primary dust measuring instrument was the

gravimetric sampler operated at 1.7 L/min with the 10 mm Dorr-Oliver cyclone and a 37 mm PVC filter. The pumps featured automatic compensation for changes in temperature and altitude, but calibration was adjusted at the mine site using a primary standard to within plus or minus 2.5%. The filters were weighed before and after sampling to calculate overall respirable dust concentrations (which includes all dust types and particulate) based on the sampling rate and time. The filters were then analyzed using XRD following the NIOSH Analytical Method 7500 (NIOSH, 1994b), to determine the silica weight, so that the silica concentrations could be calculated.

The second type of sampling instrument was the MIE, Inc. personal DataRAM (pDR). The pDR is a real-time aerosol monitor. The instrument was operated in the active mode to monitor respirable dust. Before entering the unit, dust is classified using a 10 mm Dorr-Oliver cyclone and a pump operated at flow rate of 1.7 L/min. The pDR measures and records the concentration of respirable airborne dust (which again includes all dust types and particulate) using a light scattering technique. Light-scattering instruments offer only a relative measure of concentrations but provide a continuous record of dust levels so that concentrations can be evaluated over any time interval during the sampling period.

SAMPLING AT A DUMP/CRUSHER FACILITY

Sampling Strategy

Approximately 50% of all underground limestone mines have their crushers located underground (NIOSH, 1999) which can be a major source of silica as well as nuisance dust. In this particular case study, the mine is considering different methods of controlling dust at their underground crusher using either a push-pull ventilation system or a fan-powered dust collector. NIOSH and mine personnel agreed to complete a dust study to quantify dust levels being generated by the current operation. This would be accomplished by area sampling at key locations around the crusher to determine the dust levels generated from the dumping and crushing operations and to identify potential zones of high dust concentration.

Current dust controls for this study consisted of a 37.1 kw (50 hp) axial vane fan positioned inby the crusher as shown in figure 2. The fan was positioned in this area in an effort to prevent dust-laden air from rolling back into the intake air as the trucks dumped. The fans function was to blow dust away from the dump/crusher location and down the belt entry into the return airway. The crusher is a 222.6 kw (300 hp) jaw type rated at 907 t/h (1000 stph). The belt entry is isolated from the main developments using both permanent and curtain stoppings in crosscuts along its entire length of approximately 152 m (500 ft). The crusher operator was located in an enclosed booth that was equipped with a pressurization and filtration system. A spray bar system was used at the dump location to control dust during the truck dumping operation. Any personnel entering or working in the vicinity of the crusher were required to wear personal protective equipment.

Table 1. Dust sampler location and description for crusher survey.

Site	Location	Sampling Instruments		Description
		Gravimetric	pDR	
1	Intake	4	1	2 grav samplers on each rib, pDR on one rib
2	Dump	3	1	all samplers on rib upwind of dump site
3	Crusher	3	1	samplers at control booth above crusher
4	Belt	3	1	inby open mandoor in stopping at return
5	Return	4	1	2 grav samplers on each rib, pDR on one rib
6	Entry A	2	0	on rib in entry parallel to belt entry

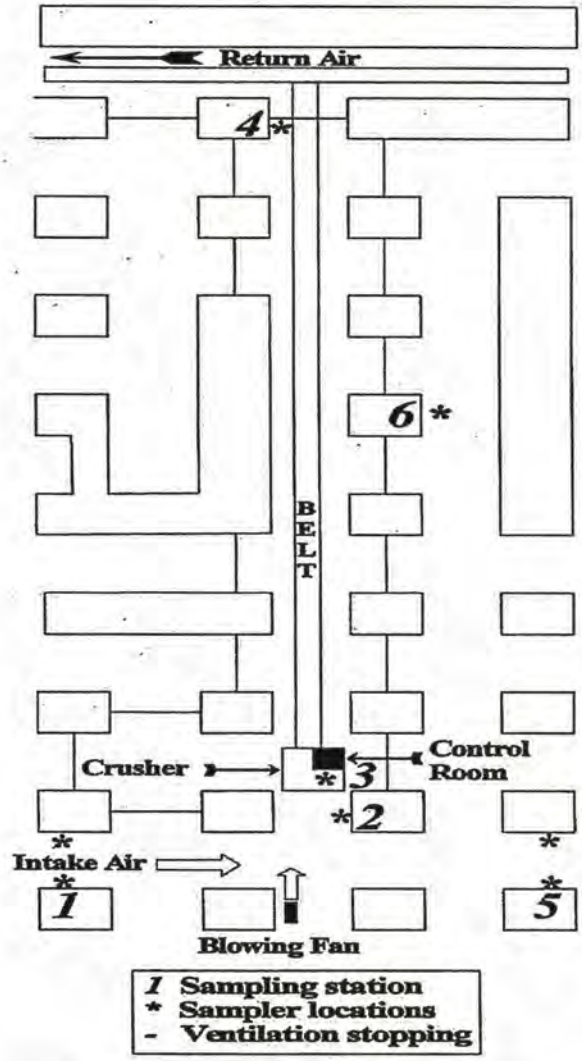

Figure 2. Location of sampling stations, blowing fan, and stoppings.

Table 1 identifies the types of dust samplers that were positioned at each sampling location, while figure 2 illustrates the relative location of these sampling stations around the crusher.

Samples were collected for three consecutive days with an average sampling time of about five hours per shift. During this time, the number of trucks that dumped and the tonnage processed through the crusher were recorded. In addition, anemometer readings were taken at a 1.2m by 2.1 m (4ft by 7 ft) doorway at the end of the belt entry leading to the return to monitor airflow from the crusher to the return airway. This information is given in table 2 and shows consistent values for all three sampling days.

Table 2. Production and air velocity measured during sampling.

Shift Number	1	2	3
Number of trucks	129	128	107
Measured tonnage, metric tons (short tons)	4624 (5098)	4711 (5194)	4214 (4647)
Average air velocity at doorway, m/s (fpm)	2.8 (565)	2.6 (506)	2.3 (460)

Results

Figure 3 summarizes the average concentrations for the 3 sampling days for the respirable dust and silica dust.

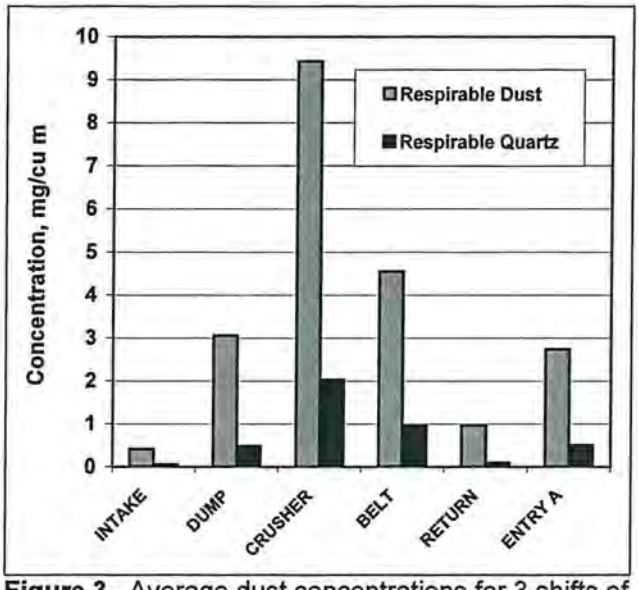

Figure 3. Average dust concentrations for 3 shifts of sampling

The following is notable for each of the six locations:

Site 1- Intake: This station had respirable and silica concentrations of 0.42 and 0.06 mg/m^3, respectively. These dust levels were the lowest observed from all locations and indicates that very little if any dust is migrating from the crusher back into the main developments on the intake side.

Site 2 - Dump: When compared to the crusher and belt, this station has lower respirable and silica concentrations. This suggests that the 37.1 kw (50 hp) fan is preventing dust rollback from the crusher as the trucks dump.

Site 3 - Crusher: This location had the highest concentrations of both respirable and silica dust. Of interest, is the fact that respirable concentrations increase threefold from the dump to the crusher location, a distance of roughly 18.2 m (60 ft). This indicates that the current fan is preventing dust migration back from the crusher, but lacks the ability to effectively move it away from the crusher. Observation from inside the operator's booth showed that during the dumping cycle a large plume of dust was created but the low air movement allowed the dust to remain around the crusher for an extended period of time. Stratification or layering of the air may be causing this effect as the fan is suspending the dust above the crusher, but is ineffectual in removing it.

Site 4 - Belt: Both the respirable and silica dust concentrations at the belt location are half of the levels at the crusher, at a distance of approximately 152 m (500 ft) from the crusher. The pDR concentration graphs from the belt were characterized by very consistent levels of dust throughout the sampling period when compared to the pDR graphs from other locations, which usually showed spiked traces of high and low concentrations. The pDR graphs in figure 4 illustrate the difference in dust patterns between the belt (site 4) and crusher (site 3) sampling stations for a typical day of sampling. Since the dust is well diluted and uniform when it reaches the end of the belt this indicates that the fan air is slowly moving the air down the entry, but not very efficiently.

Site 5 - Return: This location behaved much the same as the intake location with low respirable and silica concentrations showing that very little dust is migrating from the dump/crusher back into the main developments on the return side of the crusher. Once again, these samples suggest that the fan is preventing dust rollback from the crusher toward the intake entry.

Site 6 - Entry A: Dust levels were nearly three times higher than at the return sampling location. This indicates that dust leakage is occurring through the line curtains along the belt entry and this dust has the potential to be carried toward the working faces.

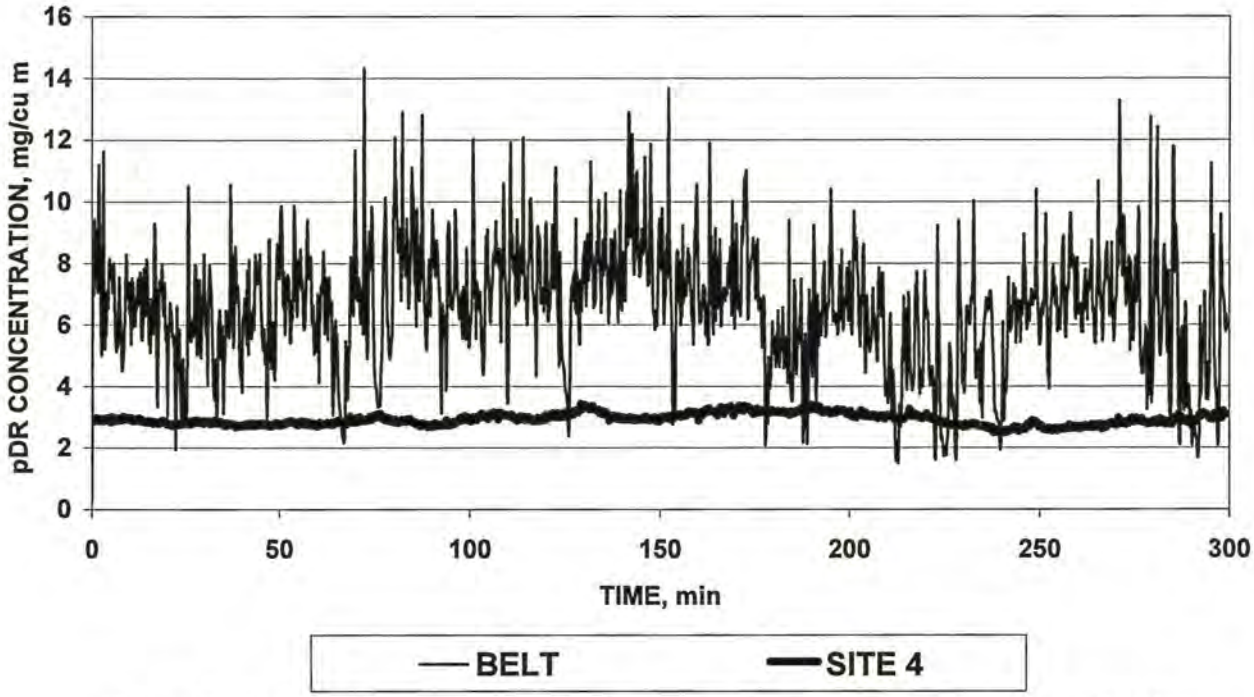

Figure 4. pDR dust levels at site 3 (crusher) and site 4 (belt) during a typical sampling day.

Conclusions

This baseline survey was conducted to evaluate dust generation and migration around an underground crusher during normal production activities. Dust concentrations around the crusher and down the belt entry were higher than desired and could be reduced with improved dust capture. The current fan location is performing a function by clearing dust at the dump and keeping it from recirculating back to the main developments. Either a push-pull system with two auxiliary fans or a fan-powered dust collector is being considered and should provide an effective approach for reducing dust levels. The push-pull system would require a second fan to be placed out by the crusher in the belt entry with exhaust tubing placed as close to the crusher as possible to maximize dust capture. Tubing will then be attached to the blowing side of the fan to transport captured dust directly to the return airway. The second alternative would involve the installation of a fan powered dust collector with filtration system to remove airborne dust and discharge clean air. Either system would increase dust capture at the crusher, thus lowering dust levels at the crusher and in the belt entry. Additionally, less dust would leak through the stoppings into Entry A.

SAMPLING DURING FACE SHOTS

Sampling Strategy

Dust generated from face shots can increase the respirable dust levels in the general mine atmosphere as the dust may not be well diluted or may have a high retention time depending on the ventilation patterns in the mine. After the blast, the dust tends to move in a cloud following the general mine ventilation course until it leaves the mine. In this study, the mine is planning ventilation changes by constructing approximately 30 curtain stoppings and installing two low pressure propeller fans to better ventilate the working faces in the mine. These stoppings and fans will increase the volume of air to the faces and establish a

directional flow of air from the eastern to the western side of the mine.

The objective of the study is twofold: 1) to document respirable dust and silica generated from face shots; and 2) to determine the retention time of the dust cloud as a means to evaluate the mine's air velocity. This baseline study was initiated to assess the current ventilation, particularly on the east side of the mine. The sampling strategy was to set up sampling stations in key locations in the mine's air course and begin sampling before the faces were shot. Gravimetric samplers would be used to determine respirable dust and silica generated by face shots. Personal DataRams (pDRs) would provide a timed record of the dust cloud arrival at these selected areas which could then be used to verify air movement patterns and quantify the mine's overall air velocity.

Location of Samplers

Nine sampling locations in the mine were selected as shown in Figure 5. Site locations were based on suspected air flow patterns in the mine and the potential of dust from the face shots in the working developments to pass that particular location and record the arrival of the dust cloud. All instrument packages were positioned on the rib, approximately 1.52 m (5 ft) above the floor. Dust samples from shots were collected on two separate days. Three face shots took place on the first day of sampling and one shot on the second day. All face shots were

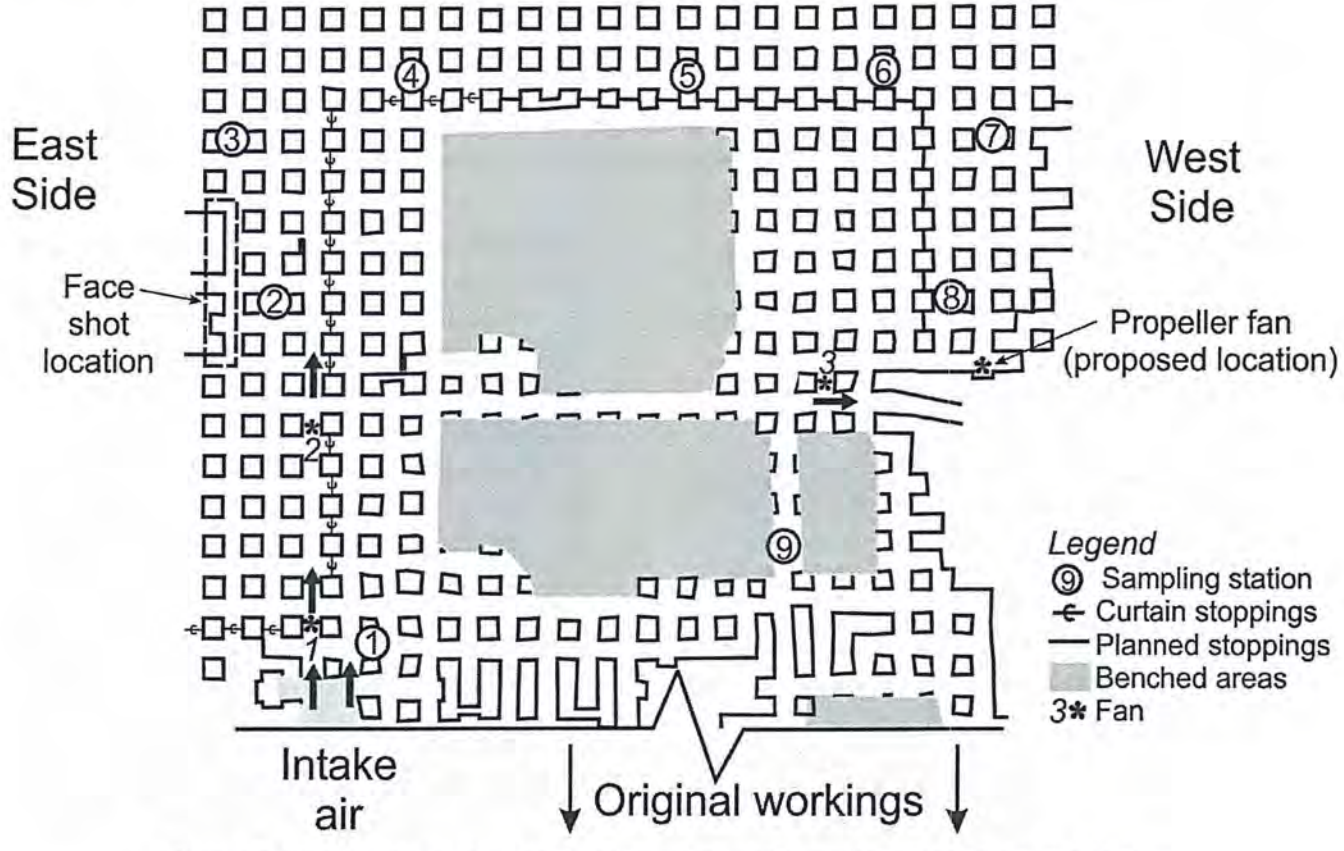

Figure 5: Mine workings showing location of sampling stations, stoppings, and fans.

on the east side of the mine, as shown in Figure 5. Also shown in Figure 5 are: 1) the location of three axial vane booster fans and their blowing direction. These fans are mobile and can be moved depending on ventilation patterns required for mining. 2) The proposed location of the low-pressure propeller fan at the west side of the mine. 3) Curtain stoppings which were built on the east side of the mine. And 4) curtain stoppings at the back and west side of

the mine that still need to be constructed. Table 3 identifies the types of dust samplers that were positioned at each sampling location.

Table 3: Dust sampler location and description for face shot survey.

Site	Sampling Instruments		Description
	Gravimetric	pDR	
1	2	1	Intake side – Monitor dust that may rollback into fresh air circuit from face shots on east side of mine
2	2	1	General air circuit - 4 sites located on inby side of the curtain stoppings to monitor dust migration from face shots on east side of mine
3	2	1	
4	2	1	
5	0	1	
6	0	1	General air circuit – 3 sites were located on the on the western side of the mine on the inby side of the curtain stoppings. They monitored dust migration from face shots on the eastern side of the mine and were used to assess the effectiveness of the air circuit being planned
7	0	1	
8	2	1	
9	0	1	Return side - Monitor dust that may migrate past the location of the main exhaust fan and into fresh air circuit

Results – Dust Sampling

Gravimetric samplers were located at Sites 1, 2, 3, 4, and 8. Figures 6 and 7 show the gravimetric data collected during the two days of sampling. It should be noted that the gravimetric samplers reflect an average concentration for the entire sampling period. For this survey, this would include the dust generated by the shot as well as an extended period of sampling with little or no dust being generated. Consequently, the concentration values are lower than the dust concentrations being generated by the face shots. If samples were taken for a shorter length of time (1-2 hrs) as the dust cloud passed a particular location the concentrations would most likely be higher (as reflected by the pDR sampling data which will be discussed later).

When examining graphs in Figures 6 and 7, several points need to be noted. First, site 1, the control intake location, had the lowest concentration with little variation in the concentration values for the two days of sampling. This indicates that booster fan 1 in the present location (see Figure 5) together with the curtain stoppings on the east side of the mine are operating effectively to prevent dust generated by face shots from rolling back to site 1, the intake. Second, on the first day of sampling, three shots took place on the east side of the mine as compared to the second day which had only one face shot. This is evident in

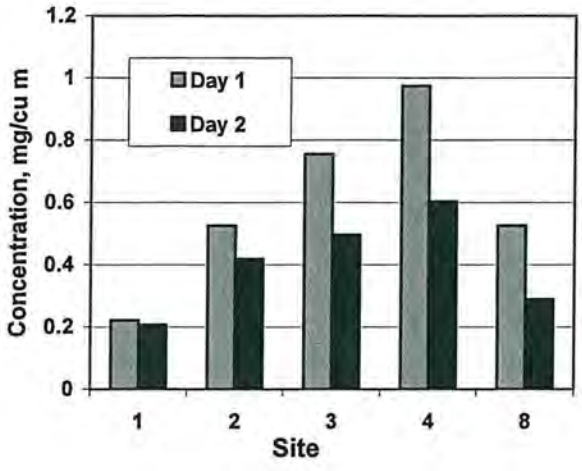

Figure 6. Respirable dust concentrations.

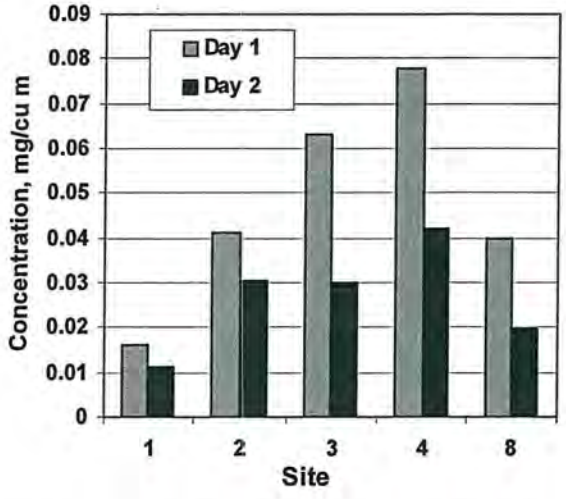

Figure 7. Respirable quartz dust concentrations.

the concentration values for both respirable dust and quartz dust which are higher on the first day at all locations. This should be expected since more shots would generate more dust. Third, the graph shows the increasing concentration from site 2 to site 4, indicating that the ventilation on the east side of the mine is moving the dust as planned. However, once the dust cloud was beyond the last curtain stopping (located two entries past station 4 as shown in Figure 5) it began to break-up and disperse through the benched areas on the west side of the mine as shown by the lower concentration at site 8.

Figure 8 shows the pDR concentrations at each location for a particular time interval, that being a 1 hr period during the peak arrival of the dust cloud produced by the face shots. This time interval was selected because pDR data showed that most of the dust from the shots had past the sampling locations within this time frame. Therefore, figure 8 represent a snapshot of the dust concentrations at each location as well as the movement of the dust. The general trend of this graph is similar to the concentration graph from the gravimetric samples in figure 6 and 7. Concentrations are low at site 1, the intake sampling location, then progressively increase from sites 2 through 4 on the mine's eastern side, then decrease at sites 5 through 9 where the last curtain stopping was installed. Again, this decrease in concentration is due to the dust cloud breaking-up and dispersing through the benched area. Once the curtain stoppings are complete on the west side of the mine and the benched area is isolated this should result in less dust dispersion and better movement of the dust from the faces.

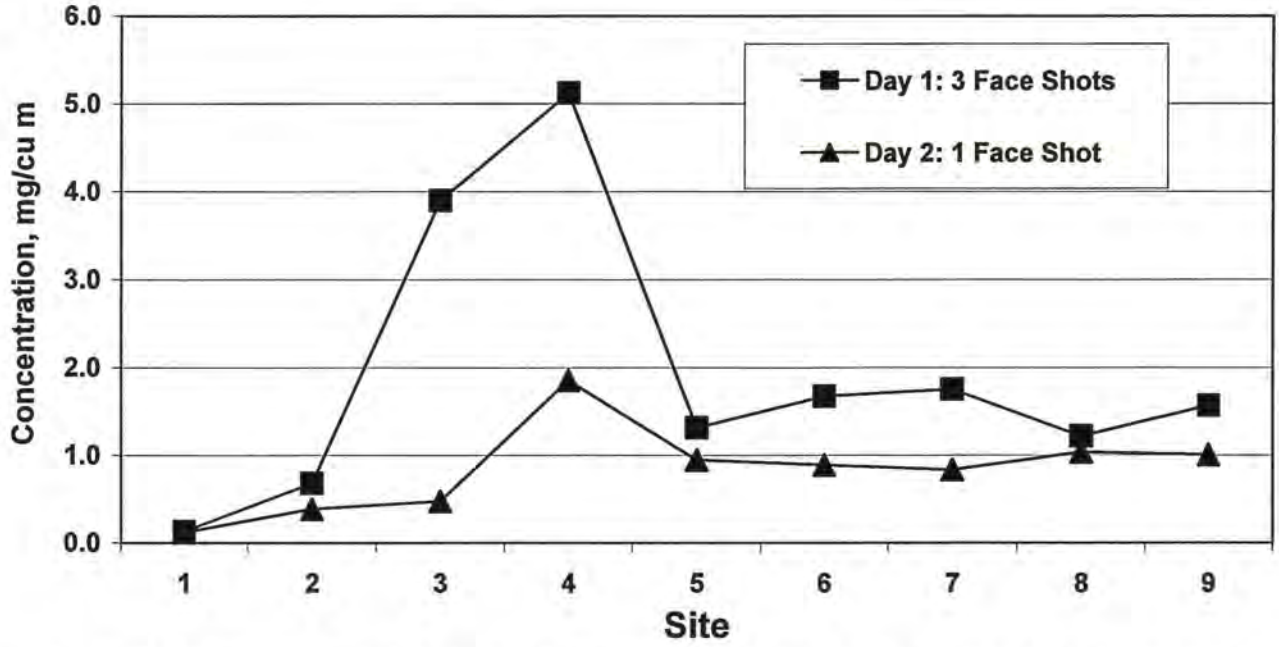

Figure 8. Average concentrations from pDRs for a 1-hour period during the peak arrival of dust from face shots.

Results - Estimate of Air Velocities

Limestone mines are classified as large opening mines where entries can exceed 12 m (40 ft) in width and 7.6 m (25 ft) in height. Commonly used air measurement techniques, such as anemometers and smoke tubes, are unable to measure extremely low air velocities associated with large openings. Tracer gases have been used successfully to assess ventilation patterns in large opening mines, but are very time consuming and costly. As a means to assess air velocities, dust clouds generated by face shots were monitored using the pDRs to time the movement of the dust through the mine.

Stations 3 through 9 were located downwind of the blast area as shown in figure 5. The pDR=s were all set to record concentrations at 10 second intervals. The concentrations from the pDRs were graphed versus time and the arrival of the dust cloud was observable as a peak concentration on the graph. Table 4 summarizes this information.

As shown in Table 4, estimated velocity show a decreasing trend with distance from the face shots. Peak concentration falls dramatically after the dust passes station 4 where the last stopping is located, but peak concentrations from the dust cloud were still apparent as the cloud broke-up and became diluted. An average of all the velocities gives a value of 0.09 m/s (17 ft/min), which would be an overall average air velocity for the entire mine. Using this value to estimate a retention time of the dust from face shot locations in the eastern section of the mine to the proposed location of the fan 3 (see figure 5) near site 8 gives a value of 1.2 hrs. From face locations closer to fan 3, on the west side of the mine, the retention time would be approximately 15 minutes.

Table 4. Estimated air velocities after face shots

pDR Location, Site #	Distance from Face Shot, M (ft)	Peak Concentration on pDR, mg/m^3	Time to Peak Concentration, min	Estimated Air Velocity, m/s (fpm)
3	36.5 (120)	12.5	5	0.12 (24)
4	122 (400)	11.5	20	0.10 (20)
5	228 (750)	1.8	35	0.11 (21)
6	288 (950)	1.7	65	0.08 (15)
7	320 (1050)	1.9	70	0.08 (15)
8	335 (1100)	1.4	100	0.06 (11)
9	350 (1150)	1.9	110	0.05 (10)
Average Velocity				0.09 (17)

Conclusions

Respirable dust concentrations from both the pDR's and gravimetrics are low at site 1, the intake sampling location, then progressively increase from sites 2 through 4 on the mine's eastern side, then decrease at sites 5 through 9. This decrease in concentration, beginning at site 5, is due to the dust cloud breaking-up and dispersing through the benched area. This is the approximate position of the last curtain stopping and the air began to short circuit into the benched area at this location. Second, the current location of fans 1 and 2 (see Figure 5) together with the completed stopping have improved air flow on the east side of the mine. Part B of the study will be initiated once the curtain stoppings are complete on the west side of the mine and the low pressure propeller fans are installed as shown in Figure 5. This should result in less dispersion of the dust into the bench area and better movement of the dust cloud from the faces and out of the mine. Third, the air velocities as calculated from the pDR data is very consistent with an average velocity for the entire mine of approximately 0.09 m/s (17 ft/min). As a result, this value gives dust retention times from face shots located in the eastern section of the mine to the proposed location of the fan near site 8 of 1.2 hrs. From closer face locations in the west side of the mine, the retention time is approximately 15 minutes. Air velocities should increase and retention times be reduced once the project is completed.

REDUCING DUST LEVELS IN AN ENCLOSED TRUCK CAB

Background

Underground limestone mining operations use various types of heavy equipment to prepare the faces for blasting and to load and haul the limestone product from the mine. Equipment commonly used at these operations include face drills, front end loaders, and haul trucks. The original cab designs on this equipment degrades through normal operation in the harsh mine environment and the protection initially afforded to the operators is compromised. Therefore, many equipment operators can be exposed to elevated levels of respirable silica

dust. In an effort to improve the protection of workers exposed to harmful dusts in enclosed cabs, NIOSH has entered into a number of cooperative research efforts with mining companies and cab filtration and pressurization companies. Several studies regarding the effectiveness of these systems have been published for surface coal operations (Cecala, et al., 2002 and Organiscak, et al., 2000). These units were installed on front-end loaders and overburden drills to reduce both respirable coal and silica dust in the operator's cab. In this study, NIOSH and Sigma Air Conditioning Inc. entered into a cooperative cost-sharing agreement to evaluate the impact of retrofitting a haul truck at an underground limestone mine with a new system to reduce the operator's exposure to silica dust.

The truck selected for retrofit with the new unit was a Euclid R-50 manufactured in 1975. This truck had multiple duties. For the most part, it was used to haul fines from the processing plant to one of two different locations. On most trips, the operator would dump the fines at an outside stockpile. Occasionally, this truck would also haul the fines into the mine and dump them for backfill. When needed, the truck would also be used to haul stone from the faces in the mine and dump them at the outside crushing facility. The truck was originally fitted with a heating and air conditioning unit that did not filter the intake air or pressurize the cab. The unit was functional, but outdated and required replacement.

The Euclid R-50 was retrofitted with a Sigma Model EC5- 0500 rooftop mounted unit. The new system had heating, air conditioning, air filtration, and cab pressurization features. The pressurizer is a 2-stage cyclonic and 1-stage particulate filter. It has a separate blower and motor to positively supply air to the return air chamber of the air conditioner. The first stage filter, has a 95% efficiency rating for particles 0.5 μm. This filter is designed to remove the larger particles and reduce the loading of the second and final stage filter, a pleated spun polyester washable medium, which is 99% efficient on particles > 0.5 μm. Installation of the unit took two 8-hr shifts and another shift of resealing the cab with foam weather stripping around the doors and service panels and caulking to seal smaller cracks. A positive static pressure of 0.01 inches of water gauge was achieved after resealing.

Sampling

The main objective of this study was to determine the impact on silica dust within the truck cab after the new system was installed. To make this assessment, gravimetric samplers were used to measure dust concentrations both outside and inside the truck cab. Baseline dust sampling was conducted before the unit was installed and sampling repeated after the installation of the new system. The position of the gravimetric samplers was the same for both the pre- and post-installation parts of the study. Their location was selected as not to interfere with operator's vision or operation of the truck. Two gravimetric samplers were positioned outside the cab below the front window, and two were positioned in the cab to the right of the operator, at the same height as the breathing zone. Sampling was conducted for three shifts before installation and then three shifts after installation. Sampling time was approximately 6 hrs per shift. During sampling, a time study was conducted on the truck and dust conditions noted for each day.

Results

Table 5 summarizes the dust concentrations values from the gravimetric samplers for the six days of sampling. The concentration values for

Table 5. Pre and post installation dust concentrations

	Outside Cab		Inside Cab	
	Respirable Dust mg/m^3	Respirable Quartz Dust mg/m^3	Respirable Dust mg/m^3	Respirable Quartz Dust mg/m^3
Day	**Pre-Installation: Original AC and Heating System**			
1	0.401	0.033	0.271	0.020
2	0.662	0.056	0.369	0.042
3	0.213	0.015	0.197	0.008
Average	0.425	0.035	0.279	0.023
Day	**Post-Installation: Sigma Model EC5-0500**			
1	1.037	0.083	0.430	0.026
2	1.069	0.068	0.288	0.016
3	0.924	0.061	0.234	0.010
Average	1.010	0.071	0.317	0.017

each day are the average of the two gravimetric samplers for that day of sampling. The "Average" row is the survey average. Figure 9 graphs the reduction in respirable dust and respirable quartz dust for the outside versus the inside of cab based on pre- and post-installation 3-day averages in table 5. The reduction of respirable dust and respirable quartz dust was 34% (0.425 mg/m^3 to 0.279 mg/m^3) and 33% (0.035 mg/m^3 to 0.023 mg/m^3) respectively, before the new system was installed. After installation of the new system, the reduction improved to 69% (1.010 mg/m^3 to 0.317 mg/m^3) and 75% (0.071 mg/m^3 to 0.017mg/m^3), respectively. Figure 9 illustrates that the new unit afforded a greater protection to the operator from outside dust levels.

Figure 9 represent the comparison of outside to inside levels of dust for the pre- and post-installation of the unit. However, to obtain an actual reduction in dust inside the cab, measured dust levels in the cab must be compared. It should be noted that the conditions for all three days, during post-installation sampling, were much dustier than during pre-installation. This was visually noted during sampling and supported by the measured dust concentration in Table 5. The respirable dust and the quartz dust concentrations

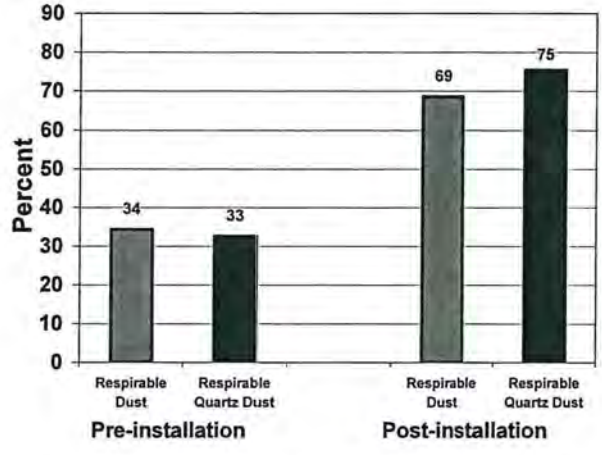

Figure 9. Percent reduction of dust in cab(outside versus inside of cab).

outside the cab during post-installation sampling are double the values during pre-installation. These higher concentrations influence the amount of dust actually penetrating the cab. This needs to be taken into account to determine the actual reduction in cab dust before and after installation of the unit. Figure 10 takes these higher outside concentrations into account by normalizing the average concentration values during post-installation to the baseline values during pre-installation inside the cab. Using this analysis, a 52% reduction in respirable dust and a 63% reduction in respirable quartz dust is achieved in the cab after the new system was installed. This is a measure of the actual improvement in the cab-working environment.

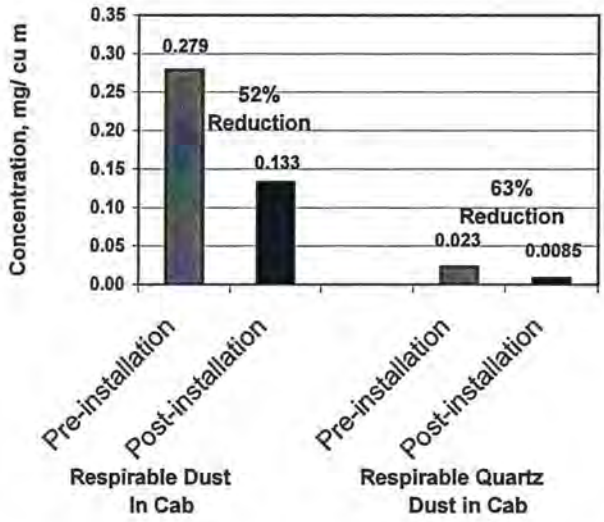

Figure 10. Reduction in dust concentrations in cab when normalizing values to baseline.

Another way to illustrate the effectiveness of the new system is by determining the increase in the cab protection factor (Heitbrink, et. al., 1998). This factor is calculated by dividing the average outside concentration by the inside concentration given in table 5. The protection factor for the respirable dust before and after installation is 1.5 and 3.2, respectively. For the respirable quartz dust the protection factor before and after installation is 1.5 and 4.1, respectively.

At this mine, several newer Komatsu trucks were operating as mine trucks hauling stone from the faces to the outside crusher. As a final measure to evaluate the new system, a 5-yr old Komatsu 100 ton truck was sampled for one day to determine the effectiveness of the pressurization and filtration system originally supplied on this truck. The number of samplers and their positioning outside and inside the cab were the same as that of the Euclid R-50. The average outside and inside respirable concentrations were 0.71 and 0.22 mg/m^3, respectively. This gives a reduction of 70% from outside to inside the cab and a protection factor of 3.3. These values are very similar to the Euclid R-50 after retrofit with the new system (69% and 3.2) indicating that the retrofitted system was equivalent to the performance of the newer trucks.

Conclusions

This field study on a haul truck at a limestone mine retrofitted with a new filtration and pressurization unit demonstrates that older model trucks can be successfully upgraded to protect the operator from silica dust. Studies have shown (Cecala, et.al., 2002 and Organiscak, et.al.,2000) that two key components for successful installation and operation are effective filtration and cab integrity. Outside air, as well as inside recirculated air, should be filtered through a high quality and high efficiency filter and the cab should be sealed to attain a positive pressure. In this study, a 63% reduction in respirable quartz dust within the cab was achieved after the new unit was installed and the protection factor for respirable quartz was increased from 1.5 to 4.1. The new filtration and pressurization system compared favorably to a newer Komatsu truck as the reduction in respirable dust and protection factor were very similar.

SUMMARY

NIOSH is conducting research in an effort to lower the silica dust exposure of workers at underground limestone mines. Dust surveys were conducted to quantify respirable dust generated by an underground crusher, face blasts, and the load-haul-dump cycle of a haul truck. These surveys evaluated current dust controls and for the haul truck, evaluated a new filtration system for the enclosed cab. A summary of each survey follows:

Underground crusher

Sampling results indicated that dumping and crushing activities at the underground crusher are liberating high levels of respirable dust. The axial vane fan currently located inby the crusher was shown to prevent liberated dust from rolling back toward the intake air entry. However, sampling results also indicate that the liberated dust is not effectively moved to the

return entry and dust is leaking through stoppings designed to isolate the crusher entry. Additional controls (another auxiliary fan or dust collector) and improved stoppings are being planned by mine management. NIOSH will conduct a follow-up survey to evaluate the effectiveness of added controls.

Face shots

Mine-wide sampling was conducted to quantify dust levels generated during face shots and monitor airflow movement/dust migration throughout the mine after the shots. The mine was in the process of installing a series of stoppings to provide directed movement of the air and dust out of the mine. Baseline survey results indicated that the stoppings constructed on the east of the mine are effectively moving shot-generated dust to sampling station 4. When the dust cloud reached the west area of the mine where additional stoppings need constructed, air velocities and dust levels dropped suggesting that the dust is dispersing throughout the benched entries of the mine. The mine is continuing to install stoppings and plans to install new fans to assist air movement and dust removal. NIOSH will conduct a dust survey in the near future to evaluate the impact of the new ventilation system on dust retention in the mine.

Haul trucks

Dust sampling was conducted to quantify the respirable dust levels present inside an enclosed cab on an older haul truck. A filtration/pressurization system was then retrofitted on this truck and the seals on the enclosed cab were improved. The cab was sampled again to document any changes in cab dust levels. Results show that quartz dust levels in the enclosed cab were reduced by over 60% with the new filtration unit installed.

NIOSH will continue to investigate control technologies that can be implemented to effectively reduce worker exposure to silica dust in underground limestone mining operations.

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QUECREEK RESCUE OPERATIONS: COMPONENTS OF SUCCESS

Ray McKinney and John Urosek

Mine Safety and Health Administration

Editor's Note:

On July 24, 2002, shortly before the start of the 33rd Institute on Mining Health, Safety and Research, an accident at the Quecreek Number 1 Mine in Somerset County, Pennsylvania left a crew of nine miners trapped. The ensuing rescue operation—a massive effort undertaken by the Mine Safety and Health Administration (MSHA), the Pennsylvania Bureau of Deep Mine Safety (BDMS), the Black Wolf Coal Company, nearby coal and mine industry personnel, state and county emergency management agencies, and local officials and volunteer agencies—became the focus of national attention.

Given the urgency of these events, the originally planned update on the Jim Walter's Disaster for the first Technical Session was canceled to allow for its presenters, Ray McKinney and John Urosek of MSHA, to update conference participants on the details surrounding the Quecreek No. 1 Mine accident and MSHA's operations which resulted in the successful rescue of the trapped miners.

As this presentation was largely prepared from emerging data and information, there is no formal textual accompaniment. However, included are a number of slides from the presentation, as well as highlights of the important facts and health and safety issues surrounding this critical event.

The mine is located in Pennsylvania, about 10 miles from Shanksville, the site of the September 11th Flight 93 crash.

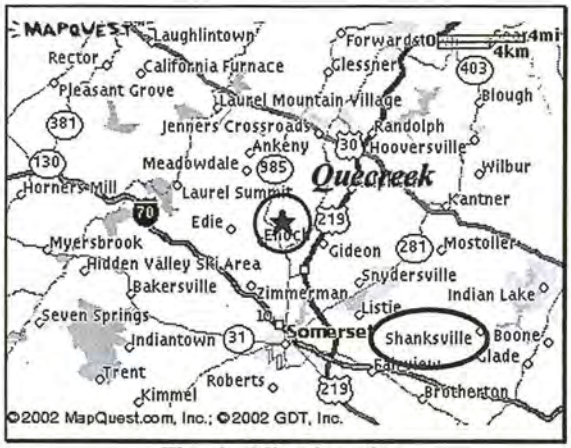


Fig. 1. Mine location

The Quecreek Mine was opened in 2001 into the Upper Kittanning Coal Seam, which was four feet thick, and with four portals from a box cut.

Fig. 2. Quecreek mine.

The Quecreek mine has two continuous room and pillar mining sections. The number 2 Left is about 6400 feet from the portals. The number 1 Left is about 7900 feet from the portals or 5300 feet from the 2 Left.

The accident involved mining crews on the 3 PM to 11 PM afternoon shift on Wednesday July 24 2002.

At approximately 8:50 p.m., miners from the number 1 Left notify miners in the number 2 Left that they have cut into water and warn them to evacuate.

By 9:45PM, water is reported at this location. The No. 1 Left miners cannot get out and reportedly travel back to section

By 11:10 PM, MSHA personnel arrive on site and a command center is established. Drill rigs are notified.

By 2:30 AM, water is reported to be at 1805 feet at the location. A 6 ½-inch borehole is started at approximately 2:50 AM.

At 5:06 a.m., the borehole enters the mine area at a depth of 231 feet. The trapped miners can be heard tapping on the pipe of the borehole. At this point the water level is at 1814 feet and is continuing to rise.

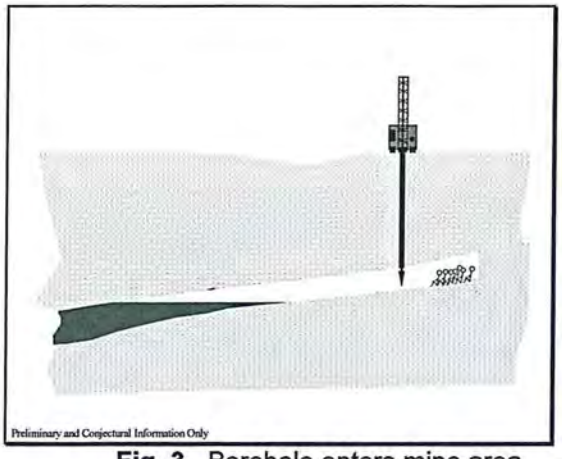


Fig. 3. Borehole enters mine area

The rising water is rapidly approaching the recently drilled borehole. The compressed air being pumped into in the mine begins leaking along the sides of the drill still. The open space was subsequently plugged, allowing the Air Pressure Theory to work.

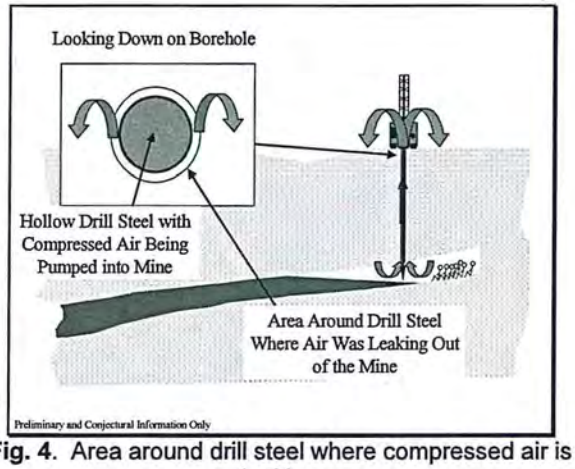


Fig. 4. Area around drill steel where compressed air is leaking

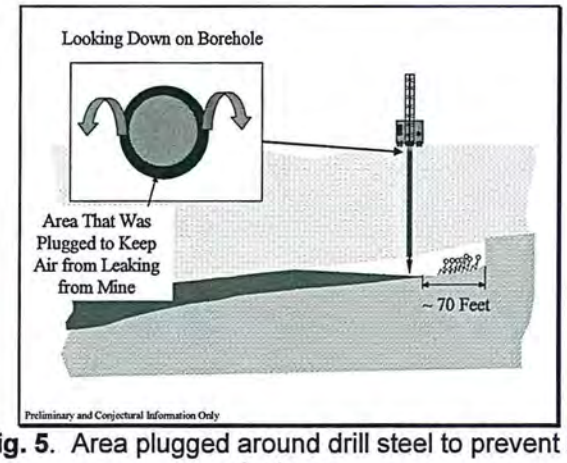
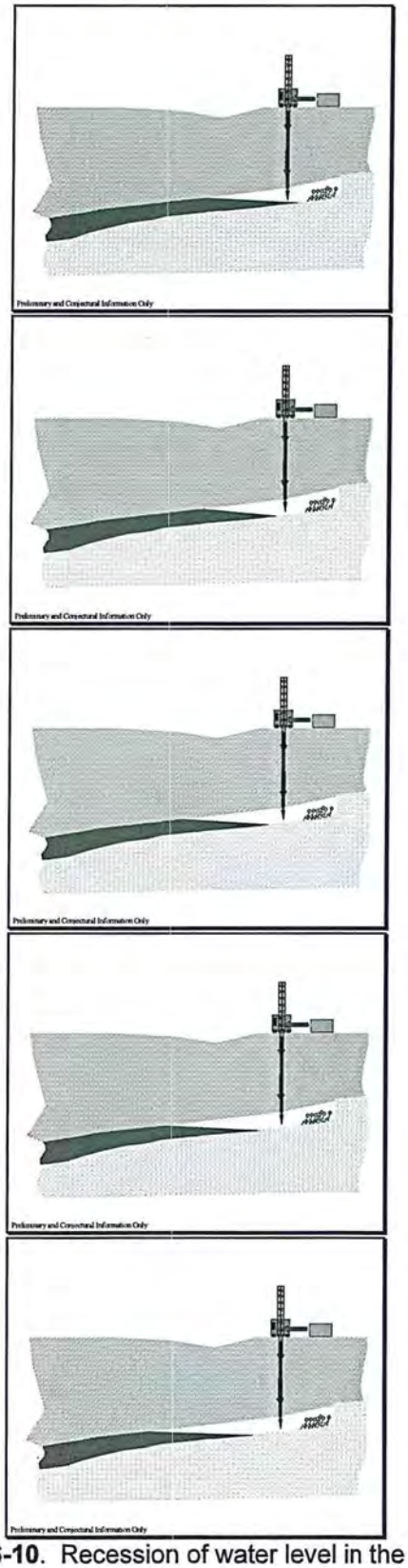


Fig. 5. Area plugged around drill steel to prevent air leakage

Once the area around the drill steel was plugged, the compressed air being pumped into the mine begins to effectively push back the water level.



Figs. 6-10. Recession of water level in the mine

By 9:15 AM, water begins to flow out of the portal. At this point the water level is 1832 feet and 1 Left is potentially already under water. At this time the diesel pumps are installed.

Fig. 11: Water begins flowing out of the mine through the portals

MSHA headquarters staff, state officials, and company officials begin contacting mining companies, vendors and even the National Guard for pumps.

Fig. 12: Large diesel pumps used at the mine site

Food for all of the rescuers is served and provided by the Salvation Army, the Red Cross, the local fire departments, the local restaurants, and neighbors.

The Pennsylvania Sate Police not only provide security, but they also escort drill rigs, pumps, and supplies to the mine site.

Fire departments provide water for the drill rigs, communications, and medical assistance and also a gathering place for the families of the trapped miners.

Briefings by MSHA, state and company officials were conducted regularly with the trapped miner families and the media.

By 4:07 PM on Thursday 25 July, water stabilizes in the pit at about 1852 feet. Three diesel pumps are operating at 15,000 GPM.

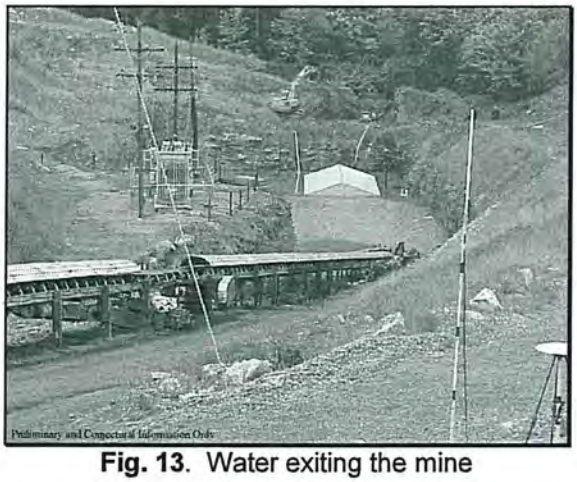


Fig. 13. Water exiting the mine

Fig. 14. Water being pumped out of the mine

At 6:45 PM. on Thursday 25 July, drilling begins for the 30-inch rescue borehole, projected for a depth of 244 feet. Drilling continues until 1:15 a.m. on Friday 25 July.

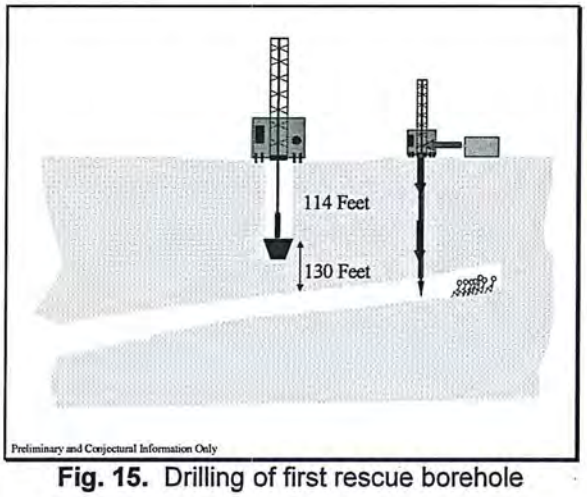


Fig. 15. Drilling of first rescue borehole

An airlock is designed and constructed to enable the rescuers to drill into the mine, remove the drill steel, and install the rescue capsule without affecting the "air bubble" in the mine.

Fig 16. Airlock

Decompression chambers are provided by the US Navy to treat miners after they are brought out of the airlock.

Fig. 17. Decompression chamber

At around 1:55 AM on Friday 26 July, the No. 1 borehole has reached a depth of 114 feet when the drill steel breaks. Efforts begin to retrieve it.

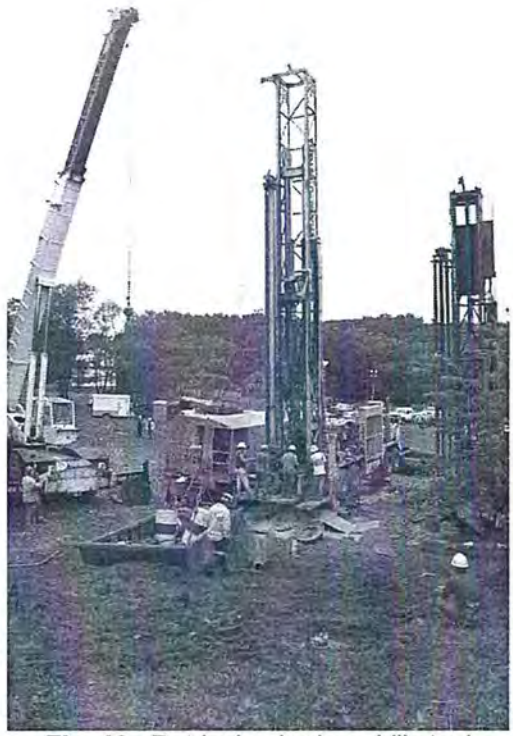


Fig. 18. Retrieving broken drill steel

By 5:12 AM on Friday, a location for a second borehole is established

On Friday at 8:00 AM, six pumps are operating in the pit at a rate of 20,000 GPM. The water level is at 1845 feet.

On Friday at 9:40 AM, a 17-inch borehole is completed into the mains near 2 Left. Water begins to be pumped out at a rate of 2,500 GPM.

By 11:30 AM Friday, drilling for the casing of the second borehole begins and is projected at 241 feet.

Fig. 19. Second borehole drilling commences

MSHA's Seismic Location System was set up near the drill site and continued to listen for the miner's throughout the course of operations. Their efforts were hampered by the noise of the air compressors and other equipment.

Fig. 20. Site of Seismic Location System

The following cross-sectional diagram of the mine shows the stage of rescue operations on Friday 26 July and includes the initial 6 ½-inch borehole, the first, failed 30-inch rescue borehole, and the second 30-inch rescue borehole.

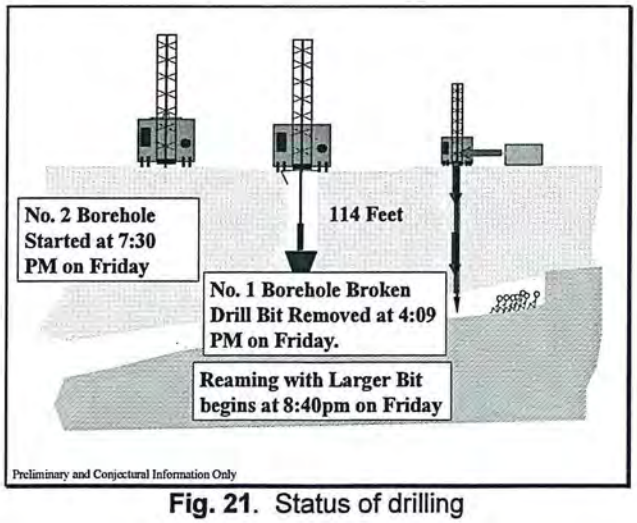
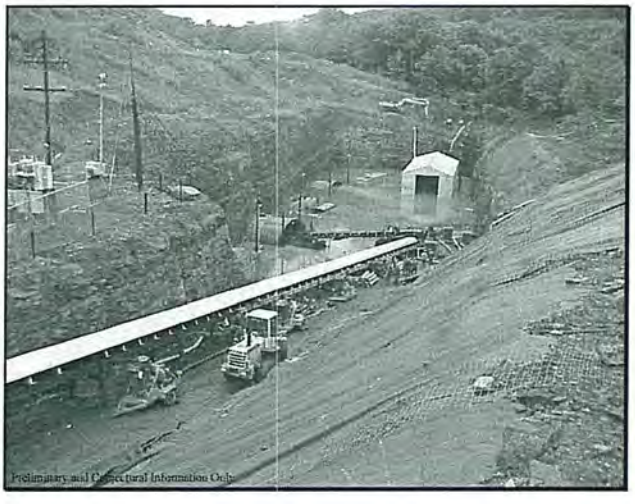


Fig. 21. Status of drilling

On-site medical personnel, including members of the Special Medical Response Team and the US Navy, express concerns about hypothermia.

By 5:00 PM Friday, the water level in the mine is about 1840 feet.



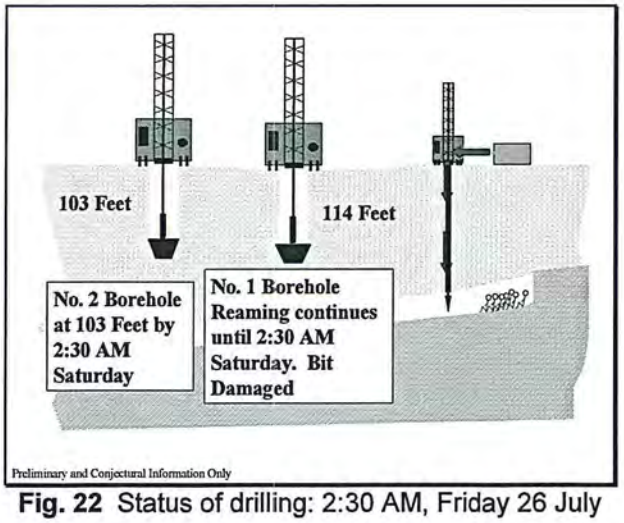


Fig. 22 Status of drilling: 2:30 AM, Friday 26 July

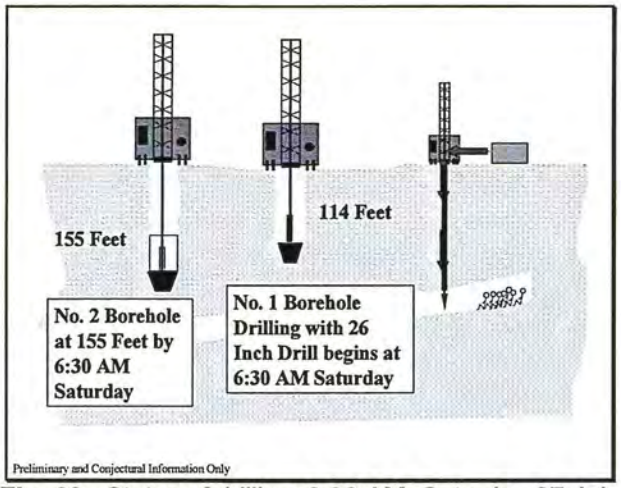
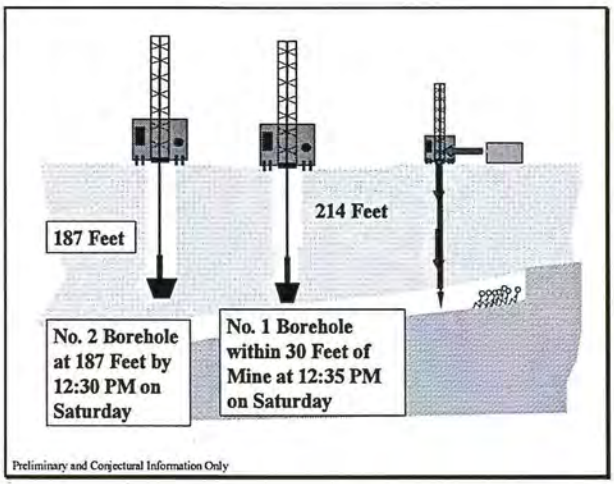


Fig. 23. Status of drilling: 6:30 AM, Saturday 27 July

At 9:30 AM on Saturday, the water level was at 1832 feet. The desired level was 1829 feet.



At 1:15 PM on Saturday 27 July, the No. 2 Borehole drill breaks at a depth of 204 feet, only 37 feet from the mine.

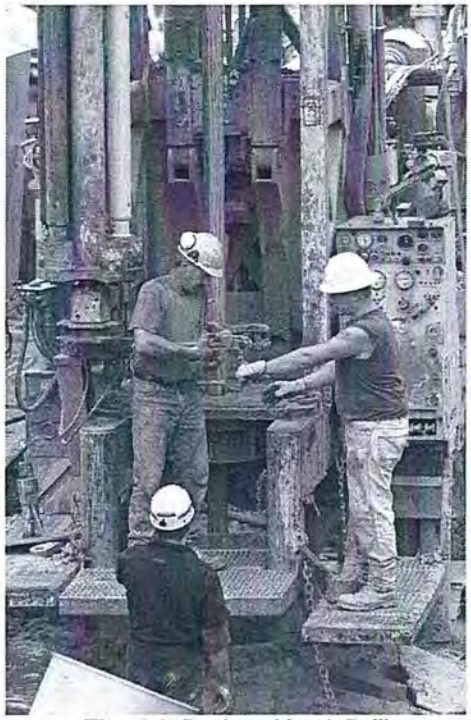
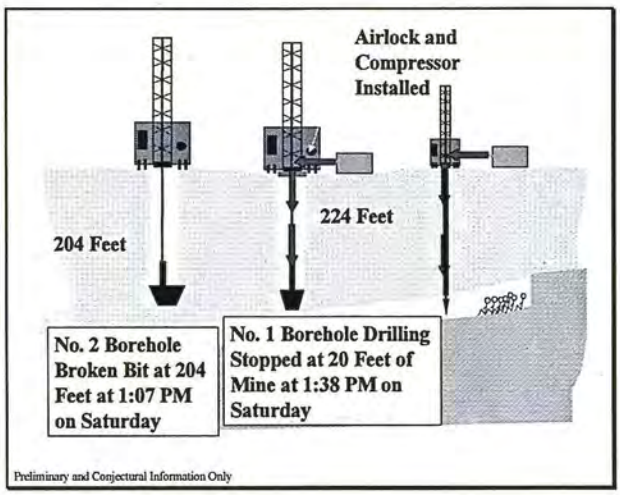
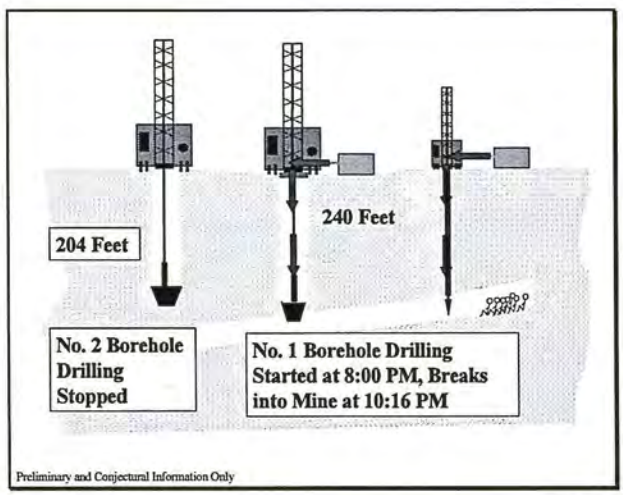
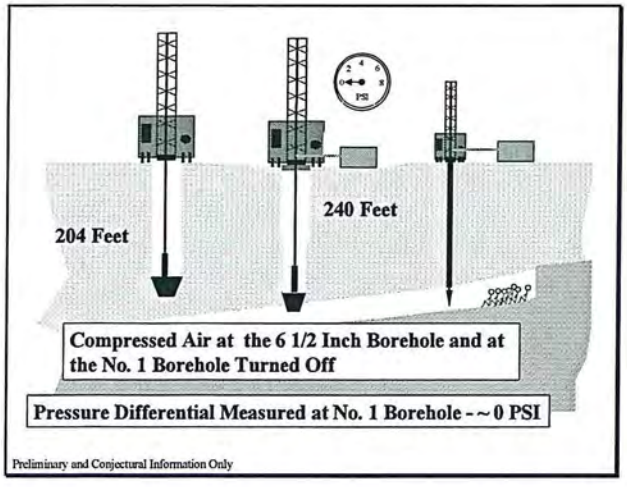


Fig. 24. Broken No. 2 Drill







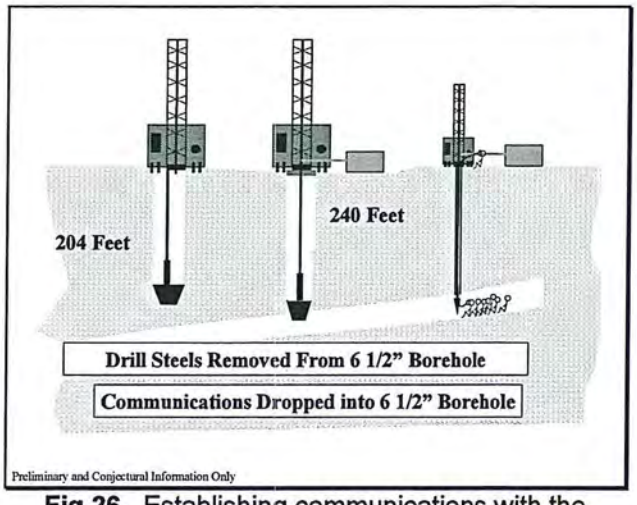


Fig 26. Establishing communications with the trapped miners

The trapped miners are heard tapping on the drill steel in the 6 ½ inch borehole. The drill steel is removed and a communications line is lowered into the borehole to the miners.

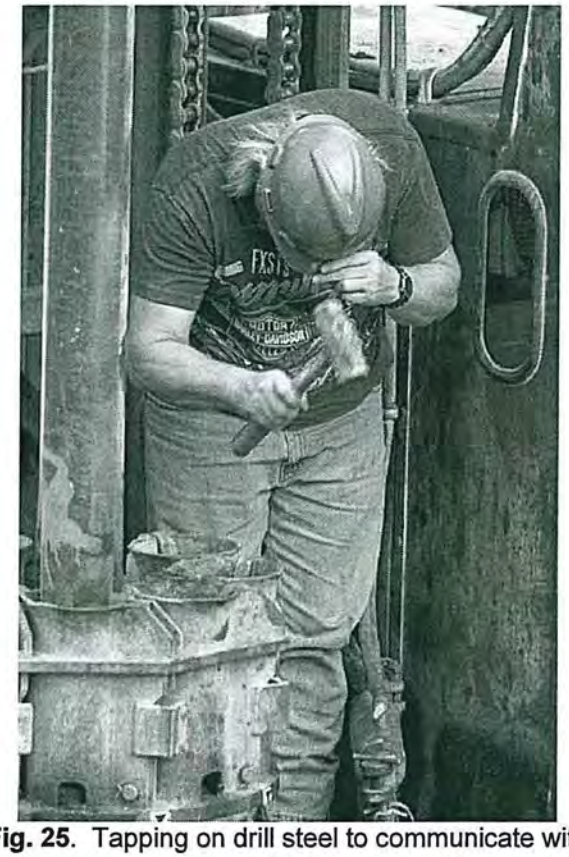


Fig. 25. Tapping on drill steel to communicate with miners

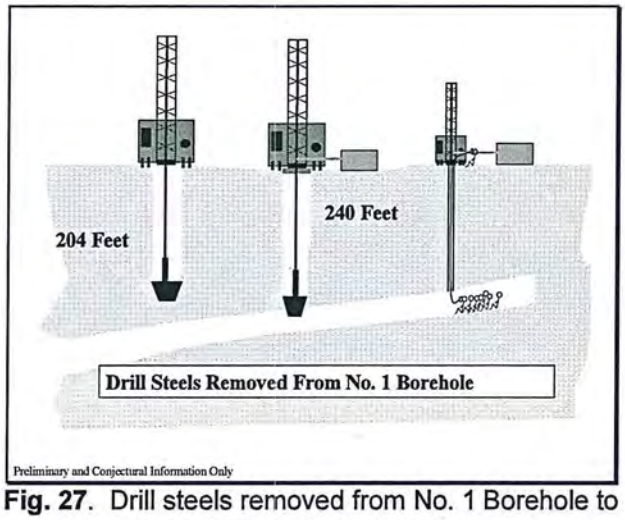


Fig. 27. Drill steels removed from No. 1 Borehole to commence rescue operations

Fig. 28. First rescued

July 28, 2002, 2:45 A.M.

"9 for 9"

TECHNICAL SESSION II:

WORKFORCE AND HUMAN FACTORS ISSUES

Session Chair

Michael K. McCarter
Professor and Chair
Department of Mining Engineering
University of Utah

PHYSIOLOGY-BASED SAFETY: THE OTHER SIDE OF HUMAN BEHAVIOR IN MINING OPERATIONS

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A 290 drifts across the centerline of the haul road and hits another haul truck head-on. A load of overburden is absent-mindedly dumped into the crusher, shutting down the mine for 12 hours. And yet another hauler drives through a curve in the road, rupturing a pipeline and dumping 85,000 gallons of raffenate into the ground. All of these incidents, and countless others like them, had three things in common. First, all of the operators were well trained and experienced. Secondly, they had excellent safety records. Thirdly, they were all working the back end of the night shift!

To say that these incidents were all due to unsafe behavior would be a gross oversimplification. None of the operators knowingly deviated from safe practices. They did not intentionally violate the "system" or break established rules, operating policies, or procedures. They failed to do the right thing because they just were not "there" mentally – any more than we were when we drove down the highway and suddenly realized we had missed our exit 10 miles back and had no recollection of the time or space in between. We call these mental lapses "microsleep," and they are a manifestation of fatigue or, more precisely, impaired alertness. When our brains are fogged in with bouts of microsleep, a thought can barely land, let alone be correctly processed. All of our training, experience, and ability are severely compromised because our biology has overridden the "system." So it's not enough to say that 90% of all mining incidents are caused by human error due to unsafe behavior. There is a missing factor that needs to be addressed if we are to resolve this human factors issue.

In fact, we now know that the majority of human error today is fatigue related, and that this state of impairment is a natural consequence of human physiology. Many still argue that fatigue is a behavioral problem, because if the operator had been getting his or her rest like they're supposed to, or if they weren't working a second job, then the incident would never have occurred. So, therefore, the unsafe act was not bad driving, but rather failing in one's responsibility to get proper rest. Well, have you ever tried sleeping in the daytime? Have you ever had to work through the night in a job that required sustained attention over many consecutive hours, performing a monotonous and boring task where only a few seconds of inattention can result in a serious accident or major production loss? While "behavior" has become the popular buzzword in the Mining Industry, the real culprit most often lurking

behind human failure – the missing factor in the safety "system" – is human physiology.

Fatigue is a fundamental physiological problem for all 24-hour operations. Our biological clocks automatically switch the human brain to low levels of alertness after lunch and during the night to induce sleepiness. As a result, heavy equipment operators are not well equipped to sustain their alertness levels and optimal performance during nocturnal hours of work, nor to gain adequate sleep during daytime hours of rest. This creates debilitating cycles of sleep deprivation that frequently leave employees in a pathologically sleepy state at all hours of the day and night. How have the mining and other industries dealt with this physiological fact of life? Simple: mess-up and we'll fire your butt! We learned that approach from the British Navy three centuries ago. "The floggings will continue until performance improves!"

The fact remains that the safe and efficient operation of our mines relies on people being at their best regardless of the time of day or night, of how long they work, of how boring their jobs and unstimulating their work environments. The bottom line is that we've set our people up to fail, and this problem is getting worse instead of better. Now they get to crash 390-ton trucks! And just to make it even more challenging – we've downsized our workforce so that everybody gets to work lots of overtime to make sure they're really good and tired!

Recent scientific breakthroughs in circadian physiology have provided insight into the direct correlation of fatigue and impaired alertness, errors of inattention, failures of logical reasoning, etc., as the major causes of human error related accidents and injuries. In fact, recent studies have confirmed that when people are tired, their ability to perform is impaired to the same level as if they were legally intoxicated (Dawson et al, 1997).

Whatever happened to mind over matter? Where are our iron men and their wooden ships? What happened to our rock-hard miners? The answer is, nothing happened. We've been the same since the beginning of humankind. What changed is that some genius went and invented electricity, and, just like that, we conquered the night and started working around the clock. This occurred in the 1880s and it created the new world of shiftwork. For the next half century, we continued to break backs and bodies through hard physical labor, but now we got to do it 24 hours a day! Eventually, equipment became more sophisticated and automated. So instead of physical fatigue, we created the modern era of mental fatigue by making most jobs boring and monotonous. And these high-tech changes in technology and equipment continue to accelerate at an incredible rate. The only thing that has remained constant is the fact that we're still human, and we still have the same physiological limitations. The past 120 years of shiftwork has done little to change that.

HUMAN DESIGN SPECS

To understand why this is, we literally have to go back to the beginning of time. As the earth made its first rotation around the sun, there was daylight and then darkness. This occurred on the same 24-hour cycle that continues to this day, and thus we have circadian rhythms. "Circadian," in Latin, means "about a day" or 24 hours. As it turns out, there are literally hundreds of circadian rhythms – we haven't even discovered them all yet. There are also ultradian rhythms (cycles shorter than 24 hours) and infradian rhythms (cycles longer than 24 hours). We humans are far and away the most complex piece of machinery on this planet. Yet, ironically, we tend to take better care of our equipment than we do our people or, for that matter, ourselves.

So, for most of human existence, we lived in harmony with the cycles of nature, literally following the sun. We rose with the sun and we set with the sun, retreating to the safety of shelter at night since we were not competitive night creatures in the primitive world from

whence we came. Thus, we were not designed for peak performance at night (Fig. 1). Our biology was formed to be active by day and to shut down at night. For millennia, this was our daily routine.

Today, however, our economy requires people to be as vigilant and alert at night as they are during the day. As heavy equipment operators, we find ourselves placed in a very compromising position. As managers, we're operating under the misguided notion that if people spent less time in the bar and more time in bed, all these problems would go away. What we're overlooking is that regardless of how much time our people spend in bed, the quality and quantity of their sleep will be compromised. And regardless of how disciplined they are in managing their daily routines, major physiological changes in human body functions are going to occur at night and after lunch – core body temperature will drop, blood pressure will decrease, hormonal secretions will change, etc., etc. We are simply programmed that way.

Figure 1

What drives these hourly fluctuations in alertness levels, sleep pressure, appetite, bathroom urges, etc. is a tiny micro-processing switch in the brain that we call our biological clock (Fig. 2). It is a discrete part of our anatomy, connected to the optic nerves, and it receives signals and time cues from the environment that activate and deactivate the biological clock.

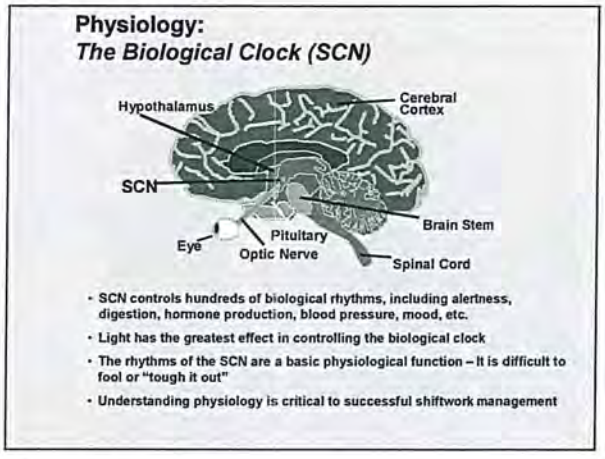

Figure 2

For example, when the human eye perceives the bright light of dawn, that signal is transmitted by the optic nerves to the SCN (suprachiasmatic nucleus) or biological clock. This generates neural impulses to different parts of the brain, causing a rush of adrenaline, a rise in core body temperature, an increase in blood pressure, etc. And so we're up and at it for the day. At dusk, or twilight, the whole process is reversed. The biological clock perceives the dim lighting, and activates the pineal gland that starts secreting melatonin, that powerful sleep hormone that you've undoubtedly heard about.

This daily ebb and flow of human physiology is kept in perfect synchronization by the SCN. As an illustration (Fig. 3), there is a significant drop in our core body temperature during the night. It's only 2.5 degrees Fahrenheit, but that's a dramatic event in the human body, putting us into a semi-state of hibernation. It's also why we sleep better in the cool than in the heat. Then, right around dawn, our biological clock kicks in, core body temperature ramps up quickly, and it remains fairly constant during the day. Now the next night, we're not sleeping. We're working the first night shift, but look what happens to core body temperature – it still drops! In other words, whether we're sleeping or not, whether we're working or not, and whether we like it or not, our core body temperature is programmed biologically to decrease at night.

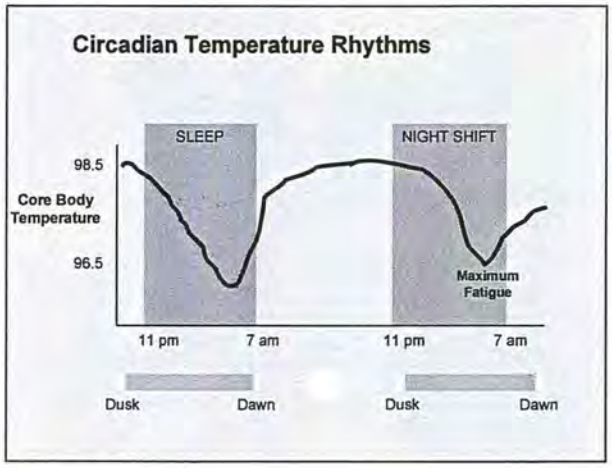

Figure 3

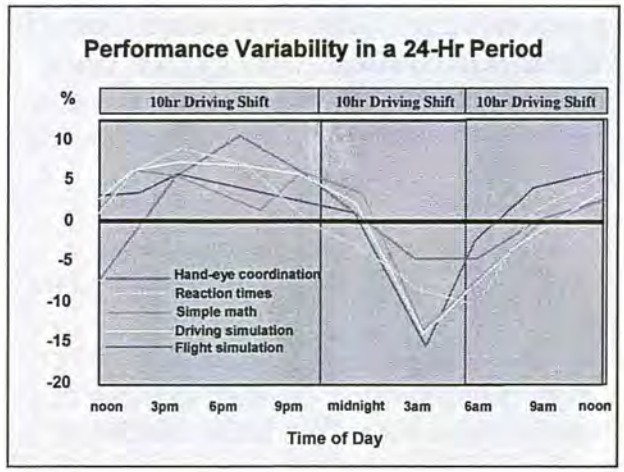

Figure 4

When we correlate this event with fatigue, it may not be surprising that maximum fatigue, or alertness impairment, occurs when our core body temperature is at its lowest point. Not coincidentally, these are also peak times of industrial and transportation accidents caused by human error.

This corollary also holds true for all types of human performance (Fig. 4). No matter how we measure it, whether through manual dexterity tests, cognitive and logical reasoning skills, or with driving and flight simulators, there is a substantial decrement in performance during the nighttime hours of lowest core body temperature. Thus, this diminished ability is most pronounced in the wee hours of the night – particularly between 1:00 a.m. and 6:00 a.m. What this also confirms is that the length of the work shift is far less important than the time of day that one has to work. If we're driving a haul truck for 8 hours during the daytime or evening shift, our performance levels are generally at full capability. However, working the same 8-hour shift through the night is quite a different story. Therein lays the fallacy of regulating the hours of service in our transportation industries.

All hours of the day and night are not the same, and 8 hours of rest does not equate to 8 hours of sleep. It depends on *when* those hours come. Thus, commercially regulated drivers can be in strict compliance with the law but operating in a totally unsafe condition. Or, they can be exceeding the limits of the law in many cases, yet performing their jobs more safely. This same paradox holds true for shorter work shifts. There is little correlation between length of shift (i.e. 8, 10, or 12 hours) and safety incidents (Fig. 5). However, there are strong correlations with time of day (Fig. 6).

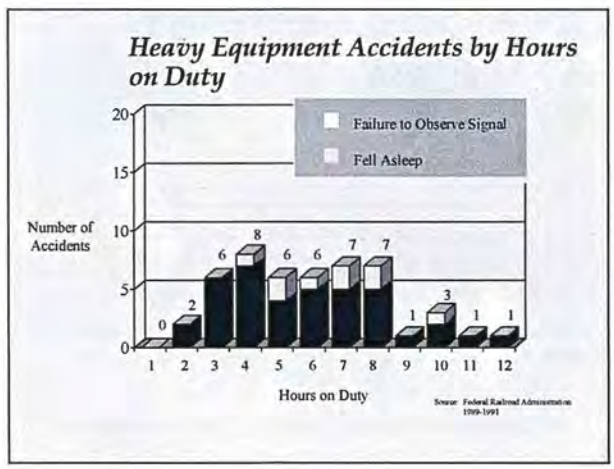

Figure 5

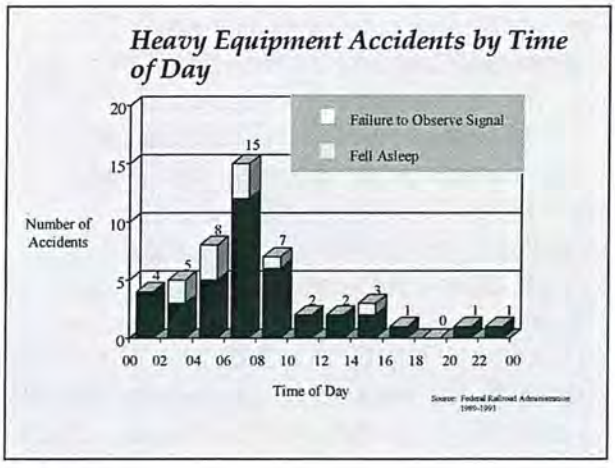

Figure 6

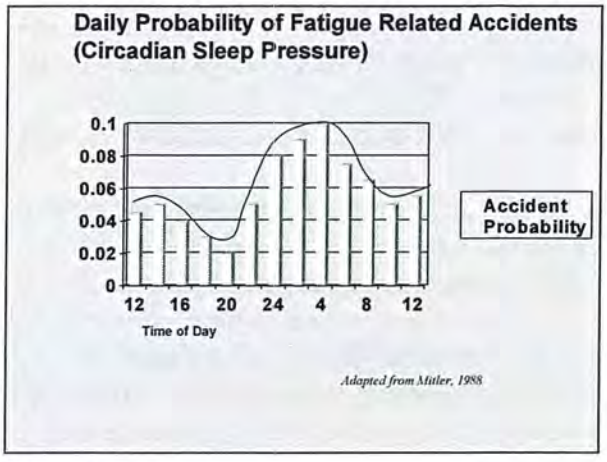

Figure 7

Moreover, if we compare the daily probability of fatigue-related accidents with our daily profile of biological sleep pressure, we observe the same circadian time-of-night effects (Fig. 7). As core body temperature drops, sleep pressure increases and fatigue-related human error increases right along with it. It defies federal regulation. You can't negotiate it away, nor can you discipline, motivate or incentivize it away. If you could, then our airline pilots wouldn't routinely nod off in the cockpit!

ALERTNESS – THE KEY TO HUMAN PERFORMANCE

It has been demonstrated by many scientists and researchers (Moore-Ede, 1993, Akerstadt, 1995) that the physiological state of human alertness is the key to human performance. By definition, alertness is that activated state of the brain when we can maintain focus and vigilance, when we're aware of the environment around us, when our cognitive and logical reasoning skills are sharpest, and when our reaction times are quick and our motor coordination skills are optimal. Moreover, it is the time when we are able to fully utilize all of the collective training, skills, and experience we've accumulated over the course of our working lives. It's the time when we most exhibit safe behavior and peak performance.

Unfortunately, unlike our sophisticated machinery that is built to operate at peak efficiency 24 hours a day, and despite our need to work safely during every hour of every day and night – the human brain was simply not designed to be constantly alert. In fact, our alertness levels fluctuate rather dramatically over the course of 24 hours (Fig. 8).

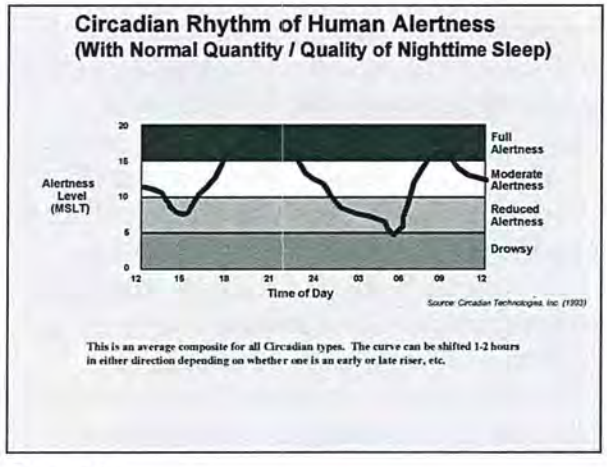

Figure 8

One of the methods that sleep researchers employ to measure alertness is called Multiple Sleep Latency Testing, or MSLT. It's a very simple test: people are asked to lie down, turn off the lights, and go to sleep. The precise onset of sleep is then determined through EEG recordings of brain activity. In the sleep research community, if a person falls asleep within 5 minutes of hitting the pillow and turning the lights out, that person is considered to be pathologically sleepy – or what we could

term dangerously drowsy. If people fall asleep within 5-10 minutes, they are in a reduced state of alertness. If they last 10-20 minutes before sleep onset, then they are considered fully alert.

With that in mind, it is important to note that alertness naturally declines after lunch, usually between 1:00 p.m. and 3:00 p.m. for most people. For a period of time, conventional wisdom attributed this to what we ate or to cultural factors such as "siesta time." But don't eat or drink and you will still experience sleep pressure in all parts of the world.

Interestingly, human alertness peaks in the early evening hours. We are at our best physiologically at 6:00-7:00 in the evening. That's when most world track and field records are broken, and when fewest motor vehicle accidents occur – even though it's rush hour! It is also the time of fewest industrial accidents – check your safety records. Conversely, human physiology literally "tanks" in the pre-dawn hours, typically between 5:00 a.m. to 6:00 a.m. for most people. Perhaps not coincidentally, this is the time of highest motor vehicle accident rates on our highways (DOT, 1995), even though there is very little traffic. It is also the time of highest incidence of industrial accidents, of lowest core body temperature, and maximum melatonin in our system. Perhaps Mother Nature is trying to tell us something. Perhaps that's why an early shift starting time is quite problematic. We typically see spikes of incidents occurring around shift turnover times under normal circumstances. Now you can exacerbate that problem by having tired shiftworkers coming to work and tired shiftworkers leaving work! No matter how disciplined or motivated you try to be, if you have to get up at 4:00 every morning to be at work at 5:00 or 6:00 a.m., you are going to be tired and not at your best.

Then comes the dawn and the resetting of our biological clocks to produce our second alertness peak in the morning. Now, this is the daily alertness curve for the average day person who's regularly getting a good night's sleep. In other words, this is as good as it gets. Thus, these normal alertness fluctuations explain the variability in human performance and reliability over a 24-hour period. Now let's take a look at the alertness curve for the night shift worker (Fig. 9). Just like before, there are two pronounced peaks and valleys during the daylight and evening hours, but the nighttime "circadian trough," as it's called, is both deeper and more protracted. This is because the typical shiftworker has been up all day, works all night, and is in effect "intoxicated" on fatigue. That's why shiftworkers tell us that the first night shift is hell! But then they say the second night shift is sheer terror! Now, why would that be?

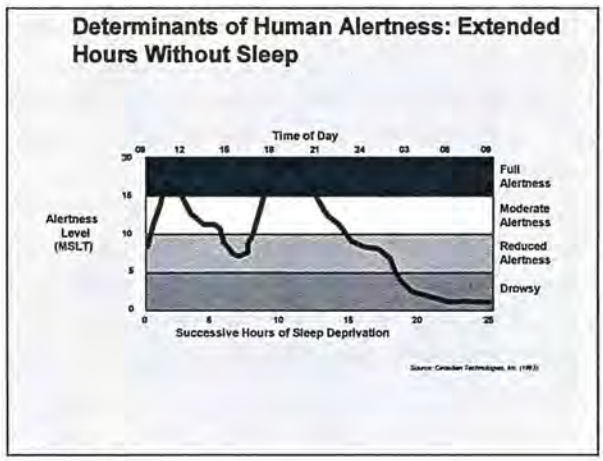

Figure 9

Because tomorrow, our heavy equipment operators are going to have to sleep during daylight for the first time in a week or two, and they will be lucky to get 4-5 hours of restless, fitful sleep. Thus they will come into the second nightshift virtually brain-dead, because they've only had 4 hours of sleep in a 48-hour period. This is of serious concern for those who have to wheel around trucks or operate a shovel the size of a two-story house! This is the type of chronic sleep deprivation that compromises the health, safety, and performances of our mine personnel. This is what creates the increased frequency of microsleep, those brief episodes of sleep pressure that come in waves of 5 to 10 to 15 seconds. We've all experienced them behind the wheel of our cars at one time or another, or in a boring staff meeting after lunch. But

imagine having to deal with it on a daily basis with potentially fatal consequences.

MICROSLEEP: THE ACHILLES HEEL OF SHIFTWORK

This is what microsleep actually looks like in your brain (Fig. 10). It's precisely measurable using EEG recordings of electrical brainwave activity. In this case we have a bus driver (heavy equipment operator) making an actual night run with a number of passengers on board. After about 2 hours into his run, he starts having microsleeps. Alpha-bursts appear on his brain wave trace, which manifest themselves as waves of sleep pressure 5-15 seconds each in duration. But this is a tough, highly motivated operator, and he fights through it! That's what dedicated shiftwork veterans do. So he gets through that episode, is in good shape for the next two hours, but then encounters another burst or two. Again, he fights his way through. So far so good. Then look what happens at 6:00-7:00 a.m. – multiple bursts of sleep pressure descend upon his brain. He's fighting it and fighting it, struggling to keep his eyes open. He's hit the proverbial "wall." Fortunately, the road didn't turn and nothing stopped in front of him. If that had happened, there would have been a serious high-speed accident. The unfortunate fact of human physiology is that, when we're microsleeping, we cannot react to changing conditions nor safely operate our equipment.

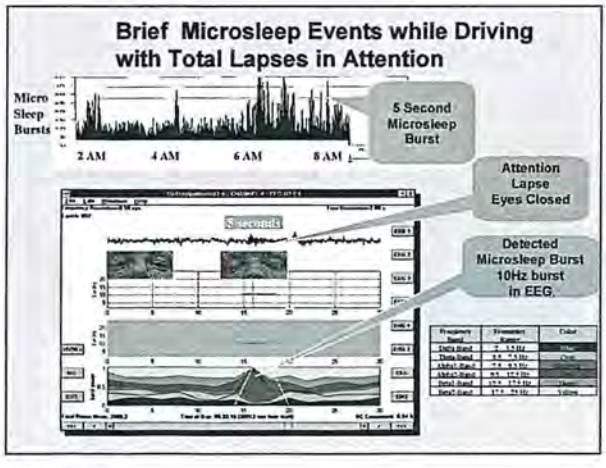

Figure 10

It may strike you as curious that these microsleeps occurred at approximately two-hour intervals. This is not coincidental. It is one of our ultradian cycles at work. Even those of us who work during the daytime experience the need for a "micro-break" every 1 ½ to 2 hours. Researchers call these "sleep gates" (Lavie et al), and this aspect of our biology has been used effectively to train astronauts and emergency ground crews how and when to nap during extended periods of work in emergency situations like Apollo 13. Unfortunately, napping is disallowed in most of our industrial workplaces and can be grounds for discipline or termination. Yet, ironically, we possess the innate capability to "power nap" our way to productivity.

I alluded earlier to a phenomenon we call "fatigue intoxication." The results of recent studies conducted by Dawson and Reid at the University of South Australia (Fig. 11), which were duplicated in tests commissioned by ABC's Prime Time Labs and conducted by Circadian Technologies, Inc., have confirmed the long held belief that people who are tired perform about as well as people who are drunk! In each case the protocol used for the tests was to keep a group of subjects awake for up to 27 hours. They were not working or performing any strenuous activities – just staying awake. However, every hour on the hour they were given a series of simple tasks to perform – matching up colors and letters on a computer screen, and tapping the keyboard as quickly as possible when numbers flashed on the screen. We also put them behind the wheel of a driving simulator for yet another gauge of their performance.

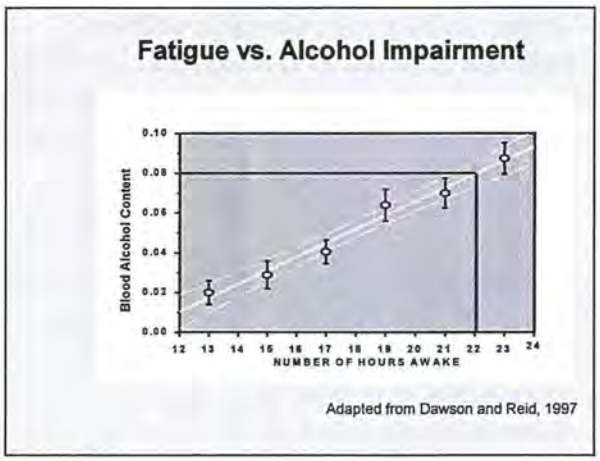

Figure 11

On another day, these same subjects were given several shots of vodka and orange juice to build up their blood alcohol concentration levels. At each level of blood alcohol concentration, they were then given the same battery of simple tests used above. Look at the straight line correlation and the very narrow standard deviations (attesting to the statistical validity of the study), which tell us that when we've been awake for just 17-18 hours (the normal day for the average person), our ability to perform the simplest of tasks is impaired to the same level as if we had a blood alcohol content of 0.05! That is about three to four 12-ounce beers for the average weight person. You wouldn't be allowed to drive a commercial vehicle or work in a nuclear power plant with that level of intoxication. After we've been awake for 21-22 hours, however, which is typical for most night shift workers – our ability to perform simple tasks is impaired to the same level as if we had a 0.08 blood alcohol content. That's the legal intoxication limit in 34 states. And, after 23½ hours, we're at 0.10 – legally drunk anywhere in North America!

Do we allow inebriated workers to operate a dinosaur-sized shovel or a haul truck that weighs over a million pounds fully loaded? Obviously not, it wouldn't be safe. Thus, we have very sophisticated alcohol testing and screening programs and strict policies and regulations to prevent this from happening. By the same token, can we have tired operators on the property who exhibit the same levels of impairment while performing even the simplest of tasks?! This is why Physiology-Based Safety is the next frontier of operational performance that we have to conquer. Fatigue intoxication is a very real phenomenon that exists as a biological fact of life. It's an inherent shiftwork problem that we've got to fix if we are to get to that next level of safety and performance. We know now that fatigue is fundamentally a physiological problem, not a behavioral problem. No matter how diligent, motivated, well trained or managed, most people will have difficulty sleeping during the daytime and staying awake at night.

UNDER-INVESTMENT IN HUMAN PERFORMANCE

The sad reality is that little or nothing is being done about it. Haul trucks continue to hit the berm, fatalities and costly property damage continue to occur, and we still to blame the operator. This is all part of a historical pattern of macho attitudes and a classic under-investment in human performance and reliability (Fig. 12). Think of where American businesses of all types have invested their money over the past 20 years. We've invested literally billions of dollars in our facilities and equipment to regain our "pre-energy crisis" global competitiveness.

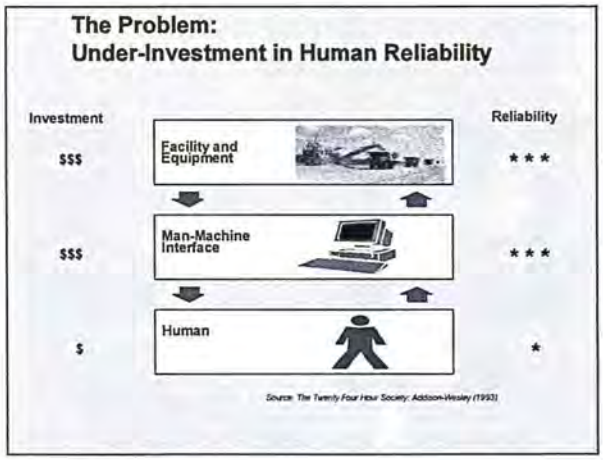

Figure 12

We've also invested megabucks in computers, automation, and systemization. As a result, these components of our operating system have become extremely reliable and efficient. By contrast, however, how much money have we invested in what every company refers to as "our most important asset" – our people? The answer is, a mere pittance. Sure, we give everyone the obligatory 3% annual raise, add a benefit here or there, and maybe provide another training program, but the reality is that all of our investment is going into equipment and technology – not into our "most important asset." As a result, the human asset has become the least reliable part of our operating system. As a further result, our people have been bypassed by technology and thus have been relegated to being passive monitors or to performing mundane, boring, and repetitive jobs that are substantially devoid of mental and physical stimulation.

Yet, make no mistake about it, our people are an integral part of the operating system. And, because high technology has eliminated most of the mental and physical stimulation from their jobs, our operators have become the least reliable link in the chain. How, then, are we to fully achieve world class this or total quality that or Kaizen or ISO 9000 or Continuous Improvement or any of those management philosophies that espouse the efficient utilization of all our assets – if we don't address the human factors issue?

The answer is, we are not. And the risks, costs, and liabilities due to the lack of human reliability are escalating dramatically. Never before have we had more assets at risk per employee. Never before have our people worked such long hours or so much overtime. Never before has fatigue produced such costly human error. So why aren't we doing something about it? Well, this goes back to the attitudes that permeate our society and our business mentality. We refuse to acknowledge or accept human frailty. After all, it's just mind over matter. No pain, no gain. Fatigue is cowardly (Vince Lombardi). Wimps need not apply. These attitudes, coupled with a lack of knowledge and understanding about human physiology and what fatigue really is, however, are just part of the problem.

Let's be crass business people. We are trained and held accountable to cost-justify every dollar of new investment with three dollars of return-on-investment. That's how businesses have to work to remain viable. Therein lies the dilemma. We can readily calculate the benefits of an $8 million piece of mining equipment in terms of reduced cost per ton, and we can thus precisely calculate the ROI to the month and the day. But how do we calculate the ROI for investments in the "soft-side" of the business? How do we cost-justify a relatively meager investment in fatigue management programs and shiftwork interventions? We may feel in our gut that this is a worthwhile investment, but historically we have had no tangible way to rationalize the cost/benefits. To quote the old management axiom, "you can't manage or control what you can't measure." That's precisely why we haven't been able to compete for budgetary dollars to invest in people – there's been no truly objective way to build a business case proposition and to objectively measure the results and return-on-investment.

The good news is, now you can. Scientific research and technology has finally provided the means to directly correlate employee fatigue and shiftwork-related problems (Fig. 13) with many factors: reduced vigilance that causes costly accidents, injuries, and liabilities; cognitive errors that cause operational mistakes, miscommunication, and poor customer service; mood deterioration that creates morale problems, absenteeism, high turnover, and labor relations problems; and impaired shiftworker health which typically runs 2-3 times the health and wellness costs of our average day workers. All of these factors add costs that severely diminish safety and operating profitability, but that also represent recoverable opportunity. Moreover, they provide a means to develop the business case proposition to compete for those

budgetary dollars and to justify investment in our human assets. This is the promise of Physiology-Based Safety, and how it offers a new, breakthrough avenue of opportunity for getting us to the next level of safety and operational efficiency.

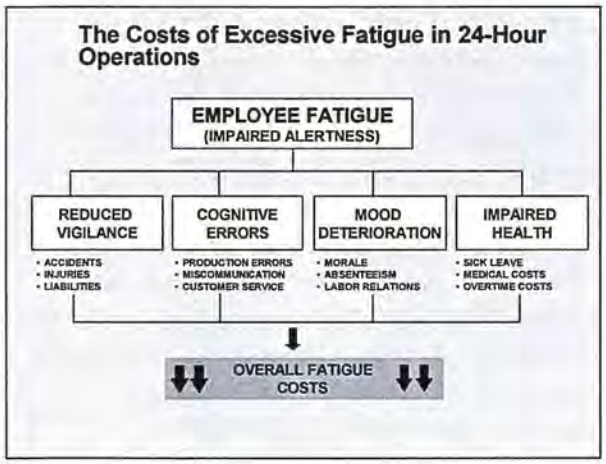

Figure 13

PHYSIOLOGY-BASED SAFETY

By now you may be wondering, "just what is this Physiology-Based Safety, and how can it be applied in my operation to reduce fatigue and optimize 24/7 workforce performance?" Simply put, Physiology-Based Safety is an objective, systematic, and cooperative process between management and labor to reduce shiftworker fatigue and its costs for both the company and its employees. It is a collection of scientific principles, methods and proven interventions that will dramatically improve the way people live and work. It is a core company value, which embraces the philosophy that everyone benefits when we provide the same care and attention to our people as we do to our equipment and technology. Just as we keep our machinery well oiled and maintained to prevent premature failure and costly downtime, so must we maintain our human assets to maximize their safe and productive performance.

Physiology-Based Safety is founded on several basic premises:

1. *Employers* have a responsibility, and a business incentive, to establish working conditions that support human performance rather that detract from it.
2. *Employees* have a responsibility, and a personal health and safety incentive, to report for work alert and fit for duty.
3. Unions and regulators have a responsibility to ensure workplace safety and employee well being.
4. All of these objectives are not mutually exclusive and they can be achieved cost-effectively with win-win results.

From an *Employer's* perspective, it certainly wouldn't make business sense to handicap your people by making them work with a 100-pound sack of potatoes on their backs. Yet, inadvertently, that's precisely what's happening to our shiftworkers. In "Gasoline Alley," that 90-mile stretch of refineries and chemical plants between Baton Rouge and New Orleans, shiftworkers have an expression for it. They call it "the bear on my back!" Come 3:00-4:00 a.m., where they hit that proverbial wall, you'll hear them exclaim in a perfect Cajun accent – "I got the bear on my back and he sure is heavy tonight!" In other words, they are feeling the weight of their physiology, and it's no different than if they had that 100-pound sack of potatoes on their backs. Clearly, it behooves management to do everything possible to get the "bear" off their people's backs.

Similarly, *employees* have to understand the special challenges inherent in shiftwork and take responsibility to keep themselves in shape, to eat and sleep properly, and to maintain their alertness levels... if for no other reason than (in the inimitable words of H.L. Boling) "somebody expects you to come home tonight." In my business experience, I have yet to meet anybody who comes to work deliberately trying to fail or to get hurt. Rather, it is a lack of training, knowledge, or plain old human factors that sets people up for failure. While there are many things a company can do to mitigate these problems, we need to empower people to take greater control over their own performance and

well being. Unfortunately, and with limited exception, they have simply not been given the tools to do this on a consistent, day-to-day basis.

With the new knowledge and information that exists today, this equation can be completely altered. Are union leaders and government regulators interested in improving employee health, safety, and quality of life? You bet. And the same knowledge and information that will improve a company's operating efficiency and productivity will also help to fulfill the union and regulatory objectives. This is what creates the win-win opportunity. This is what provides a new cooperative bridge that enables management and labor to work together for the common good. There are no losers in Physiology-Based Safety. There are no hidden agendas or mousetraps, provided everybody works together and is committed to making it happen. And for those naysayers who've heard this too many times before, ponder this: before the company can obtain its share of the results, the employees have to first perceive the benefits themselves. In other words, the employees get their "win" first. If they don't feel better, sleep better, get healthier, or feel more alert, then the company gets nothing but the satisfaction that they tried to do the right thing for their people. It's a no-lose proposition for the unions and employees, and an incentive for the company to see to it that its employees do, in fact, realize their health, safety, and quality of life benefits.

PHYSIOLOGY-BASED SAFETY IMPLEMENTATION PROCESS

There are several well-defined steps in the Physiology-Based Safety Process that will enable this to happen. Consistent with many change management processes, the first step is to educate management at all levels of the organization on the basic principles of human physiology. Why do these shiftwork problems exist? What is the extent and magnitude of their impact on the company? What can be done about it? How can this be implemented? And what is the cost/benefit/ value proposition? Until the entire management organization from the CEO on down to the first-line supervisor is on the same page of understanding, until there is consensus and commitment to the program – there is no point in engaging the workforce. It makes no sense to educate and energize the employees if the various elements of the program are not going to be fully supported by the company. That will only create frustration and ultimately prove the naysayers right, as the whole initiative begins to fall apart. To prevent this from happening, a series of management briefings culminating in organizational consensus needs to be systematically rolled out.

Concurrently, the same briefings are provided for the union committee and shop stewards. It is just as important that they receive the same information so they can make informed decisions as to the merits of supporting such a program for their membership. For until consensus in achieved within the union organization, there is obviously no point to proceeding further. And it is probably a good idea to provide briefings for MSHA to demonstrate that you are being proactive in improving safety, and to solicit their understanding and support for your initiative. Change is always hard, and problems do occur along the way. Should an incident occur in the midst of implementing the program, it's important that everyone understands the long-term viability of the program and the importance of staying the course.

Once consensus and understanding is achieved, it is generally advisable to conduct a Fatigue Risk/Operations Assessment to determine the extent of the problem and magnitude of the opportunity. This can be accomplished with diagnostic surveys of the shiftworkers and an assessment of operating data to determine the circadian correlations. Objective testing can also be performed, if desired, to establish a scientific benchmark for the program and provide unequivocal data on fatigue and alertness levels.

FATIGUE RISK ASSESSMENT

A good starting point is to evaluate accidents, injuries, turnover, absenteeism, medical costs, performance errors, etc. from a circadian physiology perspective. Just looking at safety costs in this way for the first time can be quite revealing (Fig. 14).

Figure 14

Similarly, productivity costs (Fig. 15), variable costs (Fig. 16), and even the risks associated with driving home from the night shift all provide valuable data for building the business case proposition and overcoming the financial cost and workload inertia to go after fatigue on a top priority basis. There are also a number of testing methods available to accomplish this scientifically. Among the most practical is the use of Performance Activity Monitors (PAMs) in conjunction with Circadian Alertness Simulation (CAS) software.

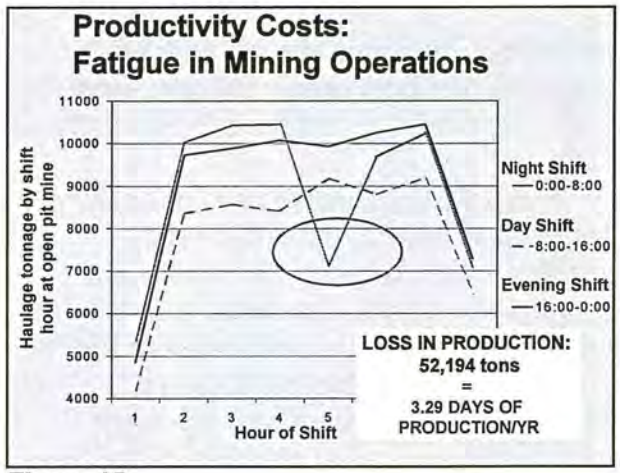

Figure 15

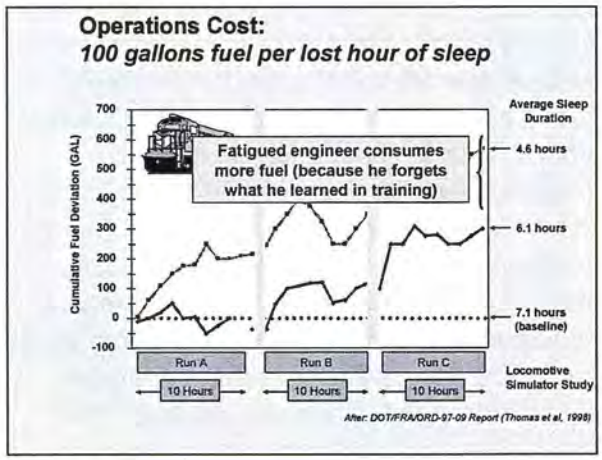

Figure 16

The PAM device (Fig. 17) looks like an overgrown wristwatch, but it is really an accelerometer that measures muscle activity. When we're awake, our muscle activity is high, and when we're asleep it's really quite low and shows up as white space in the computer printout of the downloaded recording. This provides a very objective measure of an individual's sleep-wake cycle, typically over a full 28-day schedule period. Groups of 20-40 volunteers are recruited to participate in these tests, and they wear the monitors on their wrists or ankles 24 hours a day except when showering. Any outside "artifacts," such as the vibration of a truck cab, are factored out to ensure accurate results.

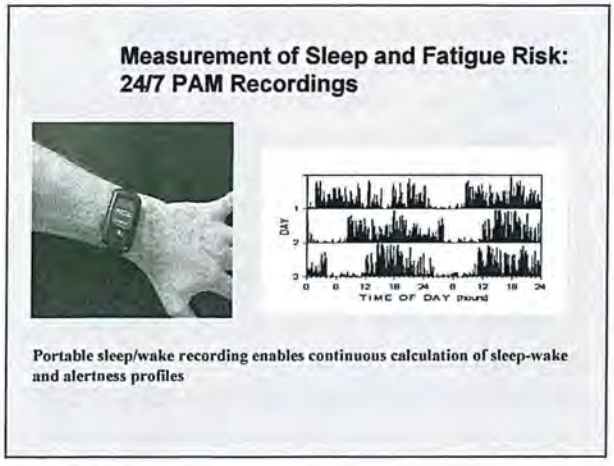

Figure 17

These results can be graphically charted into what is called an Activity-Rest Cycle or ARC Model (Fig. 18, CAS Input) to visually illustrate one's wake-work-sleep cycle. The more regular the patterns, the better rested and more alert the individual. In this example, there is considerable irregularity in the sleep pattern, and this can cause fatigue in most people.

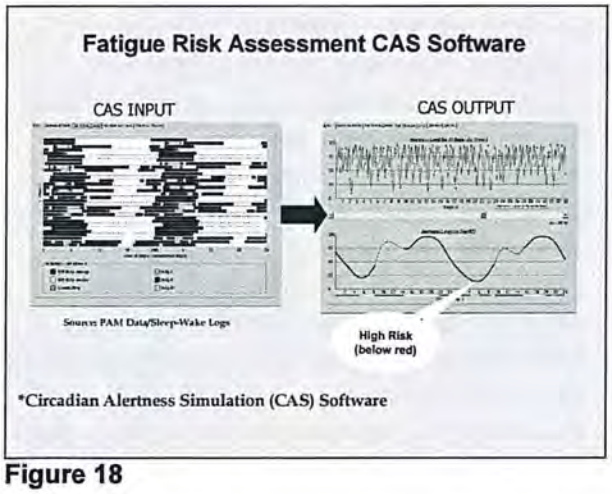

Figure 18

The real measure of fatigue, or impaired alertness, however, comes from downloading the sleep-wake data into the CAS Model (Fig. 18, CAS Output). In the top half of the chart, the CAS Model prints out the alertness levels for each individual for a full 28-day shift cycle. As indicated, alertness levels rise and fall each day as programmed by our circadian physiology. When alertness levels are below the red (or bottom) line, we are in the dangerously drowsy zone. Between the red and yellow (middle) lines is the state of reduced alertness, when we are just as apt to fall asleep as to stay awake in a boring situation (such as during a staff meeting after lunch or behind the wheel of a car or truck).

On or near the green (upper) line, we are fully alert and able to perform to our level of capability. The CAS program will also break out and enlarge one or two days to focus on an incident or a particular time of day when a critical task needs to be performed. Thus, the program will scientifically identify one's state of alertness at the precise time of an incident, and/or provide an overall assessment of how fatiguing a particular shift schedule may or may not be. Other key input factors include day of shift, time of day, number of consecutive shifts worked, the amount of overtime worked in the previous week, etc.

Thus, the Fatigue Risk Assessment provides the baseline data needed to build the business case justification for the Physiology-Based Safety program, and to develop the tactical and technical approach for its successful implementation. Given that alertness promotes safety and performance, we need to assess the determinants of alertness in the total shiftworker environment (Fig. 19). The objective is to help every shiftworker to report for work fully alert and ready to go, to be able to perform to their fullest and safest capability throughout the shift, and to be safe to drive home. Well, we know what factors drive "Alertness Reporting for Duty":

1. Time of day (circadian factors)
2. Sleep quantity and quality
3. How long one has been awake (i.e. to what extent they are "intoxicated" on fatigue)

Figure 19

If we then examine what factors impact sleep quality and quantity, we'll find that the shift schedule is a major driver. How much overtime one has worked is also a critical factor, particularly in today's work environment. It is not unusual to find 20-30% overtime levels in terms of actual numbers of hours worked over and above those regularly scheduled. Worse yet, if we analyze the overtime distribution across the workforce, we'll typically find that 20% of the people work 80% of the overtime, with some individuals exceeding 1,000 hours of overtime per year. This is fundamentally an unsafe practice, due to the cumulative sleep deprivation and fatigue that occurs. It is also a criminal liability risk for the company and its managers (Faverty vs. McDonalds, 1988).

Another key determinant of a shiftworker's ability to sleep and get proper rest is how well they've been trained (if at all) to manage their rigorous shiftwork lifestyles. Unfortunately, very few companies provide programs of this kind for their shiftworkers, yet they represent the most effective way to help people take control of their own alertness management. It is not enough to dismiss the subject by insisting that it's their responsibility to get off-duty rest. We need to teach them how to do that, given the circadian factors that come into play.

Every craftsman has "tools of the trade." For shiftworkers, one of the most important tools is a quality mattress. The quality of sleep directly correlates with mattress quality, along with the entire sleeping environment, particularly during daytime sleep. Finally, one's individual shiftwork tolerance can have a dramatic impact on fitness for duty. Some individuals are highly tolerant and adaptable to shiftwork, and those in this category are typically high performers. Others do not fare well, no matter how hard they try. Given today's high turnover rates for new employees, it may be time to develop methods to identify which employment candidates are most likely to be adaptive to shiftwork from a physiological perspective.

So these are among the key determinants of one's alertness reporting for duty, and they provide a basis for designing initiatives to increase fitness for duty. But now we need to find ways to help sustain alertness levels throughout the length of work shifts. This requires methods for monitoring alertness at work, for having alertness support and recovery systems in place, and for maintaining a stimulating job and workplace environment. For example, jobs that require mental and physical interaction are much more stimulating to the human brain than sedentary jobs which are boring and monotonous. This presents a major challenge for heavy equipment operators – particularly after lunch and during the night. The dramatic effects of cooler temperature (i.e. 68-70°F), and sound and aroma stimulation provide opportunities for alertness improvement in equipment operators, and bright lighting can be used in other critical work areas where glare and reflection are not a concern. Moreover, workplace policies are often a fertile source of improvement. It helps to recognize that we're dealing with primarily physiological rather than behavioral problems. This may open management thinking as to ultradian break cycles, workplace exercise to phase delay our daily biological declines, and power napping strategies for increased productivity.

While it's certainly clear that there are numerous opportunities to improve alertness reporting for duty and to better sustain alertness

during the shift, the job doesn't stop here. We now also have a legal responsibility to help ensure that our shiftworkers drive home safely. Driver safety is the number one killer in shiftwork operations, yet the one most often overlooked. It is well documented (AAA / UNC, 1999) that night shift workers have 6 times higher vehicle accident rates than the population norm. With rotating shifts, it's double. These accident rates are further exacerbated when driving between midnight and 6:00 a.m., when operating on less than 6 hours of sleep, and when we've been awake for 20 hours or more without sleep (Fig. 20).

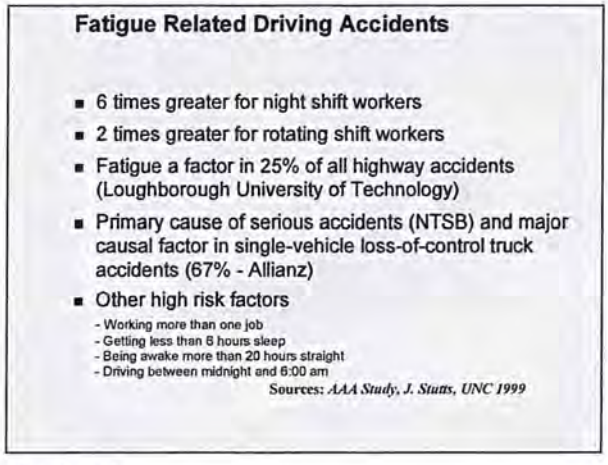

Figure 20

It used to be that employers were not responsible for off-premise accidents and fatalities. But that all changed in 1988 with a Supreme Court ruling that awarded $10 million to the family of a young shiftworker who fell asleep driving home from the night shift, drifted across the yellow line and hit another vehicle head-on, killing himself and severely injuring a mother and daughter on their way to school. The Court ruled that, just as a bartender is responsible for cutting off a drunk, so are companies and their managers required to intervene with tired employees. Accidents are foreseeable in both cases, and therefore preventable by management. Thus, if scheduling practices are not reasonable by industry norms, if there are no clear policies in place to manage overtime levels and distribution (or if rules are not being enforced), if we do not conduct regular training and awareness programs focused on this foreseeable problem, and if we do not monitor and intervene with these glassy-eyed shiftworkers coming off a double or a holdover (i.e. offer a nap, a cool shower, or a ride home), then the company is operating under a huge liability risk – not to mention inviting tragedy into the organizational family. There have been numerous fatalities resulting in multi-million-dollar awards that have contributed to what is now well-established case law on this issue.

Thus, we need to be concerned with the total shiftworker – not only because it's the right thing to do, but also because there is a tremendous business advantage to be gained. Physiology-Based Safety facilitates this by supporting operator alertness and enabling shiftworkers to fully engage with their training, experience, and skills to perform work safety and efficiently.

So, how does one put all of the pieces together and make it happen? After the Fatigue Risk Assessment has identified the opportunities, the Physiology-Based Safety Program can be developed accordingly. What specific interventions will be included? How are they going to be implemented? Who's going to be involved and/or affected? When is it going to be done? And what are the specific goals and objectives? This level of detail is needed to support the plan, and can be developed through a series of workshops (Fig. 21). The plan is then formalized, communicated, and rolled out through the organization as part of an ongoing, continuous improvement process.

The rollout of the plan begins with senior management and labor committees and continues throughout the line organization. This would be typically followed with Shiftwork Lifestyle Training – both as an intervention in and of itself, and also to provide a forum for dialogue about the problems and potential solutions of shiftwork in general and fatigue in particular. This may be supported and

reinforced with a variety of periodic publications and web counseling (online) services and followed with the step-by-step implementation of the fatigue countermeasures and shiftwork interventions determined during the strategic planning phase (Fig. 21).

Figure 21

PHYSIOLOGY-BASED SAFETY RESULTS

The results of such Physiology-Based Safety programs can be dramatic and immediate (Fig. 22-25). In one surface mining operation that was experiencing low productivity, high turnover and safety rates, and high absenteeism, across the board double-digit improvements were realized and sustained over time.

Similarly, in a billion-dollar smelting operation with carcinogen exposures, scheduling issues, and labor-management strife that resulted in two strike situations, satisfaction levels and morale soared to unprecedented levels, toxic exposures were substantially reduced, health and wellness improved significantly, and a 6% productivity increase was realized.

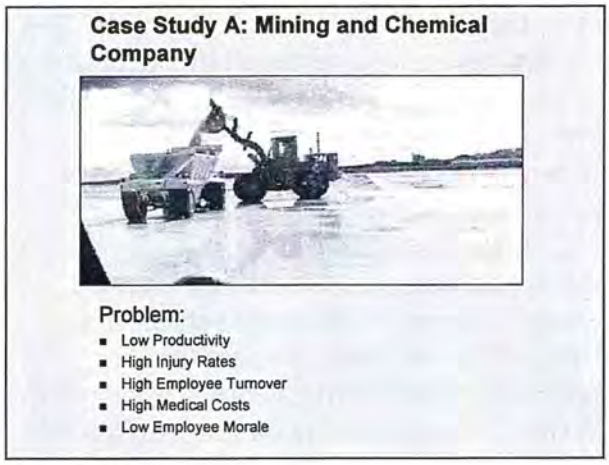

Figure 22

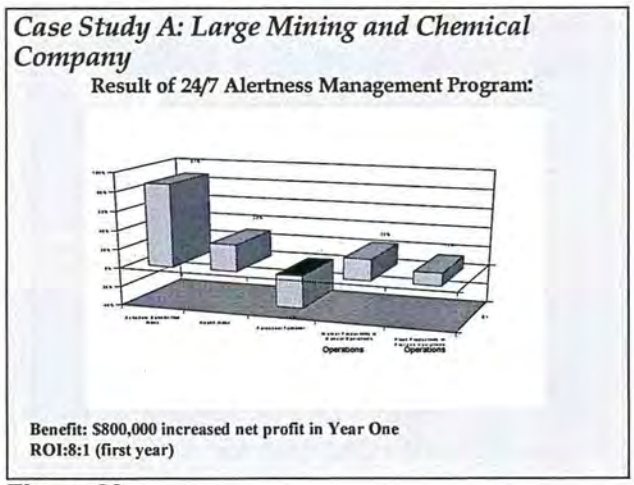

Figure 23

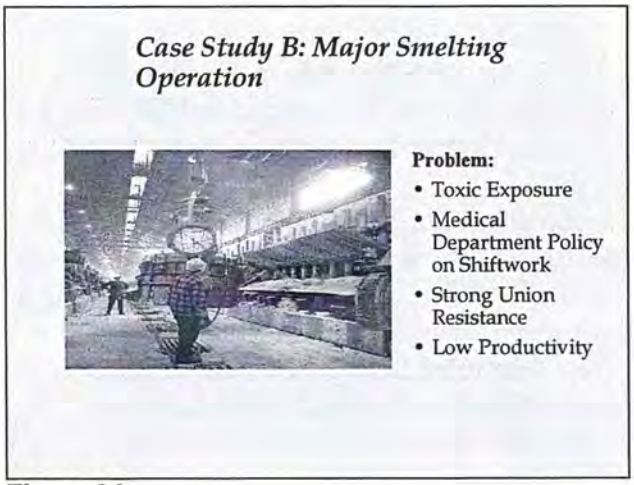

Figure 24

Thus, Physiology-Based Safety is a win-win proposition. The employees win with improved health, safety and quality. The company wins with increased productivity and operational efficiency. And the unions and regulators win because the program helps them fulfill their respective agendas as well.

Given the knowledge base and technology that exists today relative to the problems of shiftwork and fatigue, our decision is fairly straightforward. We can continue to crash trucks, ride the berm, and finance the costs of the resulting injuries, fatalities, and equipment damage – or, we can fix the problem, reap the benefits of a safer and more productive workplace, and forever change (for the better) the way we live and work in the 24/7 mining environment. The choice is clear. There are no more excuses or alibis. There is no more time, money or lives to waste. "Because somebody expects you to come home tonight."

Figure 25

MINE OPERATORS AND CONTRACTORS: PARTNERS IN SAFETY

By Adele L. Abrams, Esq., CMSP

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The creation and implementation of a contractor liability prevention program requires understanding of basic legal theories (and the Mine Act), knowledge of a particular worksite's practices and procedures (and those of the general contractor and the subcontractors involved in a project), development of policies for contractor utilization and training, written contracts and other documents that put the policy into action and provide for enforcement, and – most critically -- procedures for contractor selection, orientation, auditing and contract enforcement.

WORKER'S COMPENSATION ISSUES

Generally, worker's compensation laws provide guaranteed payments for workplace illnesses, injuries and fatalities – and in return shield employers against tort claims by their employees. A key contractor issue arises because this shield does not automatically protect employers from the claims of non-covered persons (e.g., visitors and contract employees). Thus, unless the employer is deemed to be the "statutory employer" of the contract worker, he/she may be sued in tort and subject to compensatory and punitive damages.

Some state laws specifically provide that employers who use subcontractors to perform work, instead of directly hiring employees, may be deemed the "statutory employer" and required to provide worker's compensation coverage. *See, e.g.*, Md. Code Ann., Labor & Empl. § 9-508. These types of statute create this statutory employer relationship under the following circumstances: (1) the work undertaken by the principal general contractor is part of his trade, business or occupation; (2) there is an antecedent contract under which the principal contractor was to perform the work; and, (3) the principal contractor has contracted with another person as subcontractor to perform this work. The good news is that, where such a "statutory employer" relationship is found to exist, the worker's compensation laws provide an exclusive remedy for wrongful death or personal injury claims, absent findings of willful violations of applicable laws (in some states) or intentional injury of the worker.

MSHA JURISDICTIONAL ISSUES

MSHA has enforcement authority over all mine operators and owners, as well as independent contractors who perform work at mine sites. All persons performing work at mines, who are exposed to mine hazards, are considered "miners" under the Act. The term "mine" is broadly construed to include coal, metal and non-metal mines, aggregate operations, cement plants, portable crushing operations, and even off-site maintenance shops that repair mine equipment.

MSHA and the Occupational Safety & Health Administration (OSHA) have an

interagency agreement that defines the limits of each agency's jurisdiction. It can be found on MSHA's Website at www.msha.gov.

Some of the more confusing jurisdictional issues have to do with coal-fired power plants, maintenance shops off-site that repair equipment used at both mines and construction operations, asphalt plants located in proximity to mine sites or operated by the mining company, distinct companies that run ready-mix operations within the parameters of a mine, and so-called "milling" plants that purchase already-processed materials mined by different companies and create a distinct new product for sale to downstream OSHA-regulated customers. Some of these issues have been litigated repeatedly and MSHA's approach still seems to vary from region to region. Obviously, contractors should be notified up-front when they will be entering the "MSHA Zone" and be subject to the diverse requirements in 30 C.F.R.

One recent decision may alter the landscape of MSHA's jurisdictional claims with respect to contractors. Last month, the U.S. Court of Appeals, 7th Circuit, ruled that MSHA cannot assert jurisdiction over a driver employed by a steel supply company while delivering products to a quarry site. The ruling in *National Illinois Steel Supply Co. v. Secretary of Labor* (2002 U.S. App. LEXIS 12200, June 20, 2002), which involved a Vulcan Materials Co. mine site, reversed decisions of both an ALJ and the Federal Mine Safety & Health Review Commission.

Vulcan's arrangement with NIS called for the NIS employees to deliver steel to the mine site, driving down an access road to various delivery points, where it is unloaded using equipment owned and operated by Vulcan's miners. Prior to the issuance of the citation at issue, NIS workers would help the unloading process by loosening the ropes and chains that secured the load to the NIS's flatbed truck. Occasionally, NIS employees would also help guide the hook of a crane hoist in order to rig the load. These activities occurred once or twice per week, and took about one-half hour per visit.

NIS was cited by MSHA after an inspector saw an NIS on top of the steel that was loaded on NIS's flatbed truck, guiding a crane's hook. The worker was not tied off with a safety belt or line to prevent fall hazards. Vulcan's miners were in the area running the equipment and assisting but no Vulcan supervisor was present. NIS was cited under 30 CFR § 56.15005 for failure to wear fall protection. The inspector classified NIS as an independent contractor performing a service (delivery and rigging of steel) at the mine, which would confer MSHA jurisdiction, and both the ALJ and Commission agreed with MSHA's claims.

The Circuit Court analyzed the definition of "operator" under the Mine Act and considered NIS's argument that it was performing only incidental activities at the mine that were not closely related to the mining process and were not conducted under the direction of Vulcan. The court distinguished NIS' activities from those where independent contractors have been deemed "operators" because they are involved in mine construction or extraction , have a "continuing presence" at a mine, or perform significant services at a mine. The 7th Circuit held that NIS' work at the mine was "de minimis" and nothing distinguished its delivery of steel at the Vulcan site with deliveries made by parcel delivery companies that deliver mine supplies. It concluded that NIS' actions fell outside MSHA's jurisdiction under the plain language of the Mine Act and that is was not within the definition of "independent contractor" or "operator" because its actions did not rise to a level that could be construed as "services performed at a mine."

CONTRACTOR ENFORCEMENT POLICY

MSHA's policy is to issue citations and, where appropriate, orders to independent contractors for violations of applicable provisions of the Act, standards or regulations. This policy is based on the Mine Act's definition of an "operator," which includes "independent contractors performing services or construction" at mines. MSHA defines "*Operator*" as "any owner, lessee, or other person who operates, controls or supervises an underground mine; or any independent contractor identified as an operator performing services or construction at such mine."

MSHA's enforcement policy regarding independent contractors does not change production-operators' basic compliance responsibilities. Production-operators are subject to all provisions of the Act, and to all standards and regulations applicable to their mining operations. This overall compliance responsibility includes assuring compliance by independent contractors with the Act and with applicable standards and regulations.

As a result, both independent contractors and production-operators are responsible for compliance with all applicable provisions of the Act, standards and regulations. This "overlapping" compliance responsibility means that there may be circumstances in which it is appropriate to issue citations or orders to both the independent contractor and to the production-operator for a violation.

Enforcement action against a production-operator for violations involving an independent contractor is considered appropriate by MSHA in the following situations: (1) when the production-operator has contributed by either an act or by an omission to the occurrence of a violation in the course of an independent contractor's work; (2) when the production-operator has contributed by either an act or omission to the continued existence of a violation committed by an independent contractor; (3) when the production-operator's miners are exposed to the hazard; or (4) when the production-operator has control over the condition that needs abatement.

In addition, the production-operator may be required to assure continued compliance with standards and regulations applicable to an independent contractor at the mine. It is not unusual for the mine operator to be cited with a higher degree of negligence than received by the contractor, because MSHA theorizes that the mine operator is more familiar with the legal requirements under the Mine Act and 30 CFR Parts 1-199; MSHA may also prosecute mine supervisors individually under Section 110(c) for failing to prevent violations by contractors, if the mine supervisor knew or should have known of the violative behavior.

Inspectors also will cite independent contractors for violations committed by the contractor or by its employees. Contractors should be aware, however, that some provisions of the Act, standards or regulations are not directly applicable to independent contractors or their work; and/or independent contractor compliance with certain standards or regulations may duplicate the production-operator's compliance efforts. It is critical to know that contractors know their rights and responsibilities to defend against unwarranted enforcement actions.

CONTRACTOR TRAINING ISSUES

Section 115 of the Mine Act provides that all miners must receive training when they are first hired, as well as on an annual basis. The training requirements apply to both mine operators and independent contractors at mines. They are codified at 30 C.F.R. Part 46 (surface aggregate and cement operations) and Part 48 (underground mines, surface coal and surface metal/nonmetal). Newly hired, inexperienced underground miners, and contractors who work underground, must receive a minimum of 40 hours of training; inexperienced surface miners must receive 24 hours of new miner training. All miners and contract workers who are exposed to

mining hazards are a regular, frequent, or extended (more than five (5) consecutive days) basis must receive this new miner training. Experienced miners and contractors who are hired or begin work at another mine site or for a different mining company must receive more limited training at the start of their employment.

All "miners"—including contractors who are involved with extraction and production activities—must receive 8 hours of annual refresher training each year. Miners and contractors must also receive "task training" when they begin a new assignment, or when equipment or conditions at the mine change. Contractors, and mine site visitors, who are not subject to mining hazards, or who visit the mine infrequently, must receive site-specific hazard training instead of the 24/40 hour new miner training. For mines covered by Part 48, this hazard training must be repeated on an annual basis. At all mines, hazard training must be repeated when conditions or processes change, or when new hazards are introduced to the work environment.

Construction workers at mine sites may also be considered "miners" under Part 46 training, and be subject to comprehensive training. However, construction workers are specifically excluded from the comprehensive training requirements under Part 48 if they fall within the following categories: shaft and slope workers, workers engaged in construction activities ancillary to shaft and slope sinking, and workers engaged in the construction of major additions to an existing mine which requires the mine to cease operations.

Contractors, construction workers, customers and visitors, who are NOT exposed to mining hazards, must receive site-specific hazard training prior to beginning work or entering active work areas. Such hazard training can be simple (posting signs or handing out information sheets) or more complex, depending upon the nature and extent of hazards to which contractors and mine visitors will be exposed.

Independent contractors required to provide training are also required to promptly produce their miners' training records to show that training has been provided. This is interpreted as before the end of the inspection day. In comparison, usually MSHA will give the contractor a full business day to present its Part 46/48 training plan. The location where the records are maintained, such as at a mine site, or at the contractor's office, is up to the independent contractor.

MSHA will issue an order under Section 104(g) of the Act to the direct employer of any miner who has not received the required training under Part 46 or Part 48. This means that a 104(g) order will be issued to the independent contractor for any persons who are directly employed by the independent contractor and are not properly trained. Similarly, a 104(g) order will be issued to the production-operator for any untrained persons directly employed by the production-operator.

MSHA policy states that the independent contractor should be issued a 104(g) order for any of his/her employees who are not trained in accordance with a plan approved under Part 48. If MSHA cannot determine who employs the untrained person, the agency will issue the Section 104(g) order to the production-operator. In addition to the Order, MSHA will issue a corresponding citation to the independent contractor or production operator for failure to provide the miner with the requisite training. Therefore, both a citation and the Section 104(g) withdrawal order will be issued. The mine operator/contractor generally will receive one penalty assessment of up to $55,000 that combines both the citation and order, but multiple penalties may be proposed under certain circumstances if numerous untrained miners are involved.

Independent contractors are not required to have an approved training plan under Part 48, but they must receive appropriate training. Independent contractors may comply with the training requirements by either making

arrangements to have their employees trained under an existing approved training plan and program (e.g., through a state grants program agency, a third party training company with an MSHA-approved trainer, or from the mine operator), or by filing and adopting their own approved training plan.

To date, a large number of the citations issued to mine operators under Part 46 have involved contractor training. These issues are still being litigated. The citations reported on MSHA's website in relation to fatal accidents at "Part 46" mines from October 2001 to present involving contractors state:

- Section 104(a) violation of 30 CFR 46.11(a): A fatal accident occurred at this operation when a contract welder fell 33 feet through a 3-foot by 8-foot deck opening. He was standing on the booster pump level next to the opening in the deck when the accident occurred. The contract welder had not received site-specific hazard awareness training prior to work being performed at this mine. The mine operator was aware of the Part 46 requirements. The Federal Mine Safety and Health Act of 1977 declares an untrained miner a hazard to himself and others.

- Section 104(d)(1) violation of 30 CFR 46.5(a): A fatal accident occurred at this operation when a contractor employee lost control of the haulage truck he was operating and was crushed beneath the rear wheels. The victim was not provided with the required 24 hours of new miner training or assigned work where an experienced miner could observe that the employee was performing the work in a safe manner. The victim had no prior mining experience. This constitutes more than ordinary negligence and is an unwarrantable failure to comply.

- A contract mechanic was fatally injured when he was pinned beneath the boom and fork attachment of a skid-steer loader that he was repairing. The accident occurred because the boom of the loader had been fully raised and had not been blocked to prevent accidental lowering. The contractor had three days maintenance experience at this mine. He had not received training in accordance with 30 CFR, Part 46.

Contractor training provides the greatest liability exposure for mine operators -- especially since Part 46 applies to truckers and to construction contractors, as well as those contract workers actually involved with extraction and production at the mine. The biggest question is precisely what type of training is necessary for different categories of contractors. Unfortunately, there is no clear answer. MSHA expects those contractors who have "regular," "frequent" or "extended" (more than five consecutive workdays) presence at the mine to have the full 24 hours of new miner training, plus annual refresher training.

Since "regular" and "frequent" are subjective terms, mine operators should err on the side of caution and require all contractors to arrive on the mine site "pre-trained" (except for those contractors whose work is clearly short-duration and will not reoccur), and this requirement should be part of any contractor prequalification process. To avoid being cited, the mine operator should ensure that the contractor has its own MSHA-compliant training plan, and should verify the 5000-23 forms (or equivalents) for each contractor worker who will be assigned to the mine site. Of course, the mine operator must still provide the mandated site-specific hazard training to supplement the contractors' initial training.

MSHA has revised its initial policy concerning training for truck drivers at facilities where Part 46 is in effect. Although MSHA previously decided that drivers with "regular exposure to off-road haul truck traffic; exposure to highwalls; and exposure to hazards directly associated with the extraction of the material" needed the full 24 hours of Part 46 training (a position that has been enforced in this manner under Part 48), the agency has now reversed itself and states that "Commercial over-the-road

truck drivers must receive site-specific hazard training, but are not required to have 24-hour new miner training. The training provided must be sufficient to alert affected persons to site-specific hazards, and be appropriate for the skills, background and job duties of the recipient."

Hazard training is required for persons who may come on a mine site but who are not miners. Examples include

- office or staff employees;
- scientific workers;
- delivery workers;
- customers, including commercial over-the-road truck drivers;
- construction workers who are not exposed to mine hazards;
- vendors or visitors;
- maintenance or service workers who are not at a mine for frequent or extended periods; and,
- maintenance or service workers who are working on non-mining equipment.

Contract miners, such as drillers or blasters, who move from one mine to another while remaining employed by the same independent contractor must receive comprehensive training initially from their employer, and are subject to the 8-hour annual refresher training requirements in addition to receiving site-specific hazard training at each mine they visit, and receiving task training as warranted when their duties/equipment change.

Generally, mine operators should be wary about providing comprehensive training to non-employees. This can expose both the mine operator and its trainers to third-party liability in the event of a contractor injury or fatality. Injured contractors (or their next-of-kin) will argue that they were injured or killed because of improper training provided by the mine operator's employees. Typical allegations include a failure to train, inadequate training, failure to disclose specific hazards, and negligent designation of instructors.

The likelihood of successful tort litigation will increase where MSHA cites the mine operator and/or its trainers for training violations, because some jurisdictions consider such citations to be negligence "per se." Thus, mine operators and trainers must think defensively from the outset, maintaining good documentation of all training that is provided to non-employees, even though MSHA does not strictly require such records for site-specific hazard training.

SPECIAL CONTRACTOR ISSUES RELATED TO HAZCOM

On June 21, 2002, MSHA finalized its long-awaited Hazard Communication Standard ("HazCom") covering both coal and metal/nonmetal mining. The rule takes effect on September 23, 2002, for mines with 6 or more employees, and on March 21, 2003, for mines with five or fewer workers. The number of employees that a contractor has may not be relevant, as they are likely to be inspected if present at a mine where enforcement is already triggered. All independent contractors performing work at mine sites will also be subject to the rule's requirements.

Although a general discussion of HazCom requirements is outside the scope of this paper, there are a few provisions that will require extra attention at mines using independent contractors. For example, the mine's HazCom program must address how both miners and independent contractors will be informed about chemical hazards and the protective measures needed. Contractors must also have a HazCom program, provide their employees with HazCom training initially and under Part 46/Part 48, and share information with the mine operator and its miners about any hazardous chemicals that the contractor brings on site.

In addition, the final HazCom rule also amends Part 46 and Part 48 training standards and will require modification of many training plans currently used by both mine operators and contractors. HazCom measures and location of

MSDSs and written plans may need to be covered in the site-specific hazard training given to contractors upon their first work at a mine. Although MSHA does not require written documentation of the initial training (the preamble indicates that inspectors can confirm compliance by interviewing miners), it is strongly recommended that mine operators and contractors take the time to document this initial training to assist in defending against potential citations if a miner or contractor denies having been trained. MSHA does require the follow-up training to be documented pursuant to Part 46/Part 48 on the Form 5000-23 or equivalent. These training records must be retained for at least two years. Falsification of HazCom and other training records can subject miners and contractors who certify training records to felony criminal prosecution.

NOISE REDUCTION CHALLENGES

MSHA's revised noise standard is now in full effect and was one of the most often cited standards in 2001. The enforcement philosophy may still be evolving, but it is clear that the standard poses challenges with respect to coordination with independent contractors. MSHA has indicated that mine operators must provide the mine's noise monitoring results to contractors, for further dissemination by them to the contract workers. Contractors who contribute to noise sources must also sample and provide the results to the mine's employees, if those workers are affected by the noise production.

Although miners and exposed contract workers are permitted to observe noise sampling activities, the standard does not include a requirement for the mine operator or contractor to compensate the miners' representative for participating in the observation of monitoring. Finally, the mine operator is required to give prior notice only of monitoring that is conducted to determine whether a miner's noise dose equals or exceeds the action level or exceeds the PEL or the dual hearing protection level. However, if contractors are involved in the work area or sampling, they too may require advance notice of planned monitoring.

With respect to enforcement policies, MSHA has indicated that if there is a single noise source that is linked to overexposure (whether to one or multiple miners or contract workers), MSHA will issue a single citation as long as all other requirements of the standard are satisfied. However, the total number of miners (presumably, both mine employees and contractors) affected will be listed on the citation and will affect the amount of civil penalty. Where multiple machines are the source of the overexposure, MSHA will issue separate citations for each overexposed miner. It remains to be seen whether MSHA will consider both machines used by miners and those operated by contract workers in a single work area when performing this analysis.

Contractors are independently responsible for complying with MSHA's comprehensive noise standard since they are deemed "operators" under the Mine Act. Thus, they must have their own plans, perform their own sampling and training, and must be aware of the substantive distinctions between OSHA's noise rule and the new MSHA regulation, in order to avoid being cited.

CONCLUSION

It is difficult for a mine operator to control hazards at its mine all of the time. When you add independent contractors to the mix, it further complicates issues -- particularly when the contractor does not have the same level of safety management experience (or knowledge of MSHA requirements) as does the mine operator. The mine operator must form a partnership of safety with its contractors. This includes:

- providing all necessary information about the MSHA requirements (or at least working cooperatively to guide a contractor toward sources of information),

- prequalifying contractors to ensure that they have sound safety programs and a culture of safety,
- providing appropriate site-specific training to contractors and ensuring that the contractor-employer has complied with any additional Part 46/Part 48 requirements,
- informing contract workers of health and safety hazards to which they may be exposed (as well as sampling results, where appropriate), and
- routinely checking to ensure that contractors are not exposing mine employees to hazards.

By forging a partnership in safety, accidents, illnesses and unwarranted MSHA enforcement actions can be avoided by both mine operator and contractor.

APPENDIX: CONTRACTOR CONSIDERATIONS

Risk Assessment. Risk assessments of planned contractor activities should be conducted to determine the degree of risk to which contractor activities will expose the contracting party's employees and property.

Selection Process. Selection criteria of contractors should include safety and health considerations of the contractor's ability to conduct the anticipated services and work in a manner consistent with the safety and health practices of the contracting party and meeting safety and health regulatory requirements. The degree to which selection criteria is set, should be commensurate with level of risk which the contractor's expected services and work will involve.

Communications. The contracting party should inform the contractor of the workplace potential hazards, rules and special procedures which will be encountered and must be followed in the normal course of delivering their intended services.

The contractor should inform the contracting party of any hazardous operations, materials or equipment that will be introduced to the workplace and could impact the contracting parties employees or operations in an adverse manner. If the contracting party has special safe work permit systems (i.e. confined space entry, hot work, linebreaking etc.) or other procedures, these shall be communicated to the contractor before initiation of the contracted service.

The contracting party should conduct a contractor orientation with the contractor. The degree of the orientation should be commensurate to the degree of risk to which the contractor will be exposed and in consideration of the degree of management the contracting party will be involved with the contractor. The contracting party shall establish a communication system with the contractor for reporting incidents that have taken place on the contracting parties premises.

The contracting party and the contractor should discuss emergency procedures before commencement of work, including evacuation procedures and determination of who shall provide emergency services for contractor employees when required.

Management Considerations. The contracting party should determine its managing role with the contractor and adjust its safety and health training and oversight obligations accordingly. The contracting party shall establish a system of monitoring contractor activities on its premises.

Procurement. A management approval process should be in place that prohibits the purchase of safety and personal protective equipment that has not been approved for use by the appropriate management. The process will include a review by qualified persons who have the expertise to determine what appropriate equipment should be on the list and coordination with the purchasing department. A chemical inventory shall be maintained. Any purchases of chemicals that are on the list shall go through a management chemical approval process before it can be introduced to operations.

HOW TO KILL YOUR COMPANY WITHOUT REALLY TRYING

Curtis Childress

CSP, ALCM, Risk Control and Training Manager,
St. Paul Companies

Editor's Note:

The following slides comprised the presentation given by Curtis Childress. As this was strictly a slide presentation, there is no textual accompaniment.

Slide 1

For a start...

- I'm probably talking to the wrong people here today

Slide 2

Some folks....

- Take YEARS to kill a business.
- It's SLOW and PAINFULL
- Lets talk about how to do it QUICKLY!

Slide 3

STEP #1

- Quit worrying about regulators
- They only go after the big guys
- **No one** can understand the regs
- What can *they* do to me?

Slide 4

Regulators ?

- Well... There's OSHA
- AND MSHA, and the EPA, and the IRS, and the INS, and the DOT, and the DOL, the Commerce Dept, the Dept of Health, the Dept of Corrections, the Dept of Defense, the Dept of Justice, The Dept of Education, Child Support Enforcement, Dept of Welfare, Dept of Energy [illegible]

Slide 5

Funny thing

- 90% of fatalities= companies with <10
- Ever hear "Ignorance is no excuse"?
- There IS help in understanding the regs
- What can they do to you ?
- Margate Florida Video

Slide 6

YOU- Personally

- You can have your own pair of these
- And a roommate named "Rocko"
- Last year the EPA costs companies $2.6 BILLION dollars
- EPA and OSHA had nearly 1000 criminal prosecutions

Slide 7

War story

- The DOT auditor was a pretty young lady
- There to audit the company's CDL program
- Company president was a crusty old soul
- He asked if she had a search warrant?
- He suggested she "Get your cute little butt outa here, & come back when you got one."
- Took her an hour. Then it got UGLY !

Slide 8

Step #2 We don't need no stinking contracts !!!

- We do business on a handshake
- We've never done it before
- A PO is good enough
- We need somebody bad
- You'll get somebody- BAD !

Slide 9

Sure, its just more paper

- And EVERYBODY knows what they are supposed to do
- Anyway, they are expensive

Slide 10

War Story

- It had rained all week
- Project was running behind. Need ONE more small dynamite shot- but the blaster was busy that day.
- The DRILLER offered to load and fire the shot- $100- cash, no checks, please.
- Can you see this one coming?

Slide 11

The shot blew flyrock

- Across the road
- Onto the next jobsite
- Where a ready mix driver was washing down his truck
- One piece of flyrock the size of a baseball hit him-
- $67,000

Slide 12

Step #3 We trust everyone

We don't waste money on audits
Myrtle has run that office for 10 years
Handles all the files, checks, invoices
She hasn't even taken vacation in 8 years !

Slide 13

War story

Myrtle is a HARD worker
Ask her for anything, she can find it
Sent 3 boys to college
Bought a new house
Drives a nice Buick
All on $14,000 a year

Slide 14

Yeah, Myrtle's hand is in the till

- So, call the cops- and your insurance company
- Except- Myrtle has been submitting fake invoices
- For minority/ DBE contracts
- When you subtract Myrtle's fakes, you don't meet the set asides for a contract you have completed- $15 million

Slide 15

Step #4 Don't waste time training workers

- They already know what they need to
- They'll just leave
- I trained 'em once
- They're too dumb to train
- They don't talk American

Slide 16

An Example:

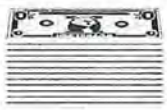
- Ybor City Florida
- Outskirts of Tampa
- May, 2000

Slide 17

Training?

- JLG operator- no training
- Fire emergencies- No training
- Fire extinguishers- none
- Total damages- $60 million +

Slide 18



Step #5 Get it CHEAP !

- That Chinese drill is half the price
- His bid is 45% lower than anyone else
- He'll sell me a Bobcat for $2,000
- Do you know how much safety glasses cost?
- Let's look at each of those for a second

Slide 19

Cheap?

- The cheap Chinese drill is NOT UL listed. The OSHA fine was $3000. The worker injury was $23,000
- Bid 45% lower? What got left out? EVERY SAFETY CONTROL !
- Bobcat-The MOST stolen piece of heavy equipment- because people will buy them for $2000!
- Safety Glasses-$6.98 Loss of an eye- $85,000.

Slide 20

Step #6
Surprise your Insurance Agent

- They won't admit it
- But they really love it!
- They all have ESP
- What he doesn't know won't hurt him!

Slide 21

War story

- Bill was a carpentry contractor
- He got some work for prefab steel buildings
- He expected to pay about $12/100 for WC
- Steel Erection- $53/100
- Work was at a marine terminal- USLHW
- $100/100
- Now he knows why he had low bid !

Slide 22

War story

Winter- work is slow- We've got this big shop

The guy next door needs new dump bodies

We've got 3 welders- we can do that

No products liability insurance

We found out what those little holes were on the frame that we left out- the safety lock pins for mechanics. After we smushed a mechanic

Slide 23

Sure, there are other things

Drug/Alcohol Prog.

Know your drivers

Don't pay taxes

Don't pay Insurance

But if you want to kill a company FAST- these are a GREAT start!

Slide 24

Oh, I know

I'm talking to the wrong folks

But if you know of someone that can use this, pass it along

For everyone else, do the EXACT opposite!

Slide 25

So at the end of the day

Everybody gets to go home

Slide 26

St. Paul Safety Services

stpaul.com

Slide 27

TECHNICAL SESSION III:

TRAINING ISSUES AND INFORMATION TECHNOLOGIES

Session Chair

John Langton
Management Officer for Coal
Mine Safety and Health Administration (MSHA)
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CONSTRUCTION, MAINTENANCE, AND REPAIR ACTIVITIES: THE DATA ON INJURIES 1993 – 1997[1]

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ABSTRACT

In past years in the mining industry, the focus has been on safety with regard to extraction and production activities. Viewing historical injury data from the 1990s within a broader paradigm, this paper focuses, not on specific injuries linked to extraction and production of minerals, but on mining injuries occurring within the context of worker construction, maintenance, and repair activities. A definition is offered for these activities. Data from all commodities and from both operator and contractor are presented. Overall in the mining industry from 1993-1997, thirty-nine percent of injuries occurred while the employees were performing activities related to construction, maintenance and repair. Implications for safety training are discussed.

INTRODUCTION

As improvement in mining injury statistics "flatlined" in the1990's, safety and health personnel, managers and miners began to discuss what the next step might be to reinstate a downward trend in injuries (1). In 1996, Richard Seago (2), Vulcan Corporate Safety Manager, presented a paper based on company data entitled "The Last Big Frontier in Safety" suggesting that activities in construction, maintenance, and repair were the key to future reduction in injury.

After a panel of experts defined construction activities, maintenance activities and repair activities, an in-house study utilizing MSHA data for the company was undertaken. After analyzing 604 accident narratives, the point was proven – that CMR activities accounted for a large 64% of injuries throughout the company, over the period studied.

The question then became, to what extent is this true throughout the mining industry, in all commodities and at all locations? The Pittsburgh Research Laboratory, NIOSH contracted with Battelle Centers for Public Health Research and Evaluation to design a study and analyze a sample of narrative descriptions over a five year period (1993-1997) with the goal of determining whether an injury incident could be characterized as one involving construction/maintenance/repair (CMR) activity. This paper is based on the findings of that report (3).

A secondary goal of the analysis was to determine the basic weighted frequency distributions of CMR-related cases, comparing mine operators and contractors by primary commodity mined and subunit within each commodity.

CODING THE DATA

"Using the NIOSH field-tested definitions of CMR given below, each record was reviewed and assigned one of the following codes

1 - CMR Related Event
2 - Activity Other than CMR
3 - To Be Reviewed

Classification of construction/maintenance/repair activities was made independent of employee occupation or job title" (3, p. 1).

Cases

A sample of 21,024 injury incidents were selected (1993 -1997) from the Mine Safety and Health Administration (MSHA) database known as the Mine, Accident, Injury, and Illness Database (n=104,108).

Construction/Maintenance/Repair Related Events

"Construction work activities involve the building, rebuilding, alteration, or demolition of any facility or addition to existing facility at a surface mine, surface area of an underground mine or underground mine. These activities would include tasks such as painting, decoration or restoration associated with those facilities or with the land connected to those facilities at the mines. However, it excludes any tasks involved in shaft and slope sinking or work performed on the surface incidental to shaft or slope sinking. Examples of construction activities would include the building of stoppings that control the airflow in the mines or the building or destruction of offices or shops at the surface of a mine.

Maintenance and repair work activities are tasks associated with the construction, installation, setting up, adjusting, inspecting, modifying, or maintaining any servicing machines or equipment. These activities may include: lubricating, cleaning or unjamming of machines or equipment, making adjustments or tool changes to any equipment or machines used in the mining process.

Other key words that assisted in the determination of a CMR event include welding, grinding, cutting, leveling, examining, splicing, booting, greasing, resetting, greasing, sewing, replacing, "working on", digging, and checking. Certain types of equipment and materials were typically considered an indicator of a CMR event. These include track, drive or take-up rollers, tail piece, head, stopping, gunnite, overcast, and undercast. Any activity that used mobile or fixed cranes — also called overhead hoist or chain hoist — or the getting in and out of the those cranes, was considered a CMR activity" (3, p. 3). Sample CMR Narratives are illustrated in Figure 1.

Activity Other Than CMR

The accidents not coded as construction, maintenance, and repair would include activities directly involved with the mining or extraction process, such as

- roof or rock bolting
- shooting, drilling, or blasting for a commodity
- operating machines or equipment directly involved in the extraction of a commodity, such as the conveyor, scoop, shuttle car, tractor, miner, or trucks
- setting up jack legs or any other temporary roof support
- scaling, adding I-beams, hauling, hanging cable, etc.

Sample "CMR" Narratives

- Injured was welding on the shear drum at face of the 16e mn longwall section a piece of roof coal fell from top, striking injured on right shoulder, neck and right hand.
- The EE was using a pry bar to unwedge a board from the D.A. Ram. He cut his right palm. He went to the emergency room after his shift. The cut required four stitches.
- Moving a track rail with a bar. Rail slipped causing bar to fly out of his hands and the bar struck him on the right cheek. Laceration and fracture to right cheek.
- Injured stated he was helping coworker make a belt splice in #3 entry on the belt line. His knife slipped and hit the inside of his left leg above the knee, causing a laceration to his left leg.
- EE was jacking the track jeep back onto the track when the bar for the jack slipped from the jack causing the EE to fall catching his fingers between the bar and the track rail, thus fracturing his left middle finger and ring finger. Actual cause of the injury was probably due to be in a hurry no rules or regulations being broken
- Shoveling on belt line bottom belt caught shovel carrying back through tailpiece between bottom and bottom belt. Shovel blade was sticking out from under tailpiece guard. Started to reach for shovel splice came through & knocked shovel blade into right cheek

Figure 1. Sample "CMR" Narratives

There were also activities not related to CMR activities or the mining process. These would include

- tripping, falling, or lifting that was not within
- the performance of CMR work
- water or coal sampling and/or testing
- the basic cleaning of facilities, such as garages, offices, shops or other various rooms
- getting in and out of trucks or other vehicles, except mobile or fixed cranes, which stated earlier are classified as CMR.

The moving or removing of boxes or equipment from trucks or other locations would not be CMR related unless the items being moved or removed were engines or any other parts that were or would be used to repair machines or equipment. In addition, the use of hand tools without the clarification of the use at the time of the accident was coded as not CMR related. Sample "Activity Other Than CMR" Narratives are illustrated in Figure 2.

Sample: "Activity Other Than CMR" Narratives

- Employee was roof bolting and wrench slipped causing him to hit his finger on a roof bolt plate that was laying on the bolter.
- A piece of draw slate way laying on top of and hanging over side of the continuous miner. As the miner operator walked around the miner he brushed against the slate with his left arm causing a laceration.
- EE was doing quality control sampling of limestone. She was taking material out of a mechanical shaken to weigh. She bent over and strained lower back.
- EE was bending over sorting parts in a box. He stood up and back went out.
- Employee was hanging line curtain, started back to operator's side, stepped on rock covered with hydraulic oil. Employee states he strained left leg.
- Lifted one end of a cross arm that resulted in a strain (hernia) of the right side groin.

Figure 2. Sample "Activity Other Than CMR" Narratives

Third Category: To Be Reviewed

The third category to be coded was primarily events that did not give any narration or stated the injury was a reoccurrence of a prior injury. These events were too unclear as to the activity performed at the time of the accident. NIOSH subject matter experts reviewed these items prior to the final report. All events coded as a "3" were reviewed and assigned as a CMR activity or as an Other than CMR activity in the final report. A total of 166 cases were returned to NIOSH coded as a "3". Only 1 of these was subsequently coded by NIOSH reviewers as "1" (a positive CMR case). "To Be Reviewed" Narratives are illustrated in Figure 3.

Sample: "To Be Reviewed" Narratives

- Reoccurrence of injury from 2-13-92. Please see 7000-1 no. 2-7-92.
- EE cut his leg with a knife.
- Employee stated that he slipped in a wider hole & sprained his left knee.
- Employee tried to lift a rock. He pulled his groin area causing him severe pain.
- The injured does not know when or how he hurt his knee. At 11:00 am he told the supt. that his knee was hurting & he wanted to go to the hospital for medical treatment. No witnesses to the injury & no equipment involved.

Figure 3. Sample "To Be Reviewed" Narratives

RESULTS

The data is presented in the following tables.

Frequency Distribution Tables:

Table 1. Observed Number of Injuries Related to Construction, Maintenance, and Repair Activities for Mine Operators and Contractors by Major Commodity Group in Sample Dataset (n = 21,024).

Table 2. Observed Number of Injuries Related to Construction, Maintenance, and Repair Activities for Mine Operators and Contractors by Type of Operation in Sample Dataset (n = 21,024).

Extrapolated Estimates:

Table 3. Extrapolated Number of Injuries Related to Construction, Maintenance, and Repair Activities for Mine Operators and Contractors by Major Commodity Group (n = 104,108).

Table 4. Extrapolated Number of Injuries Related to Construction, Maintenance, and Repair Activities for Mine Operators and Contractors by Type of Operation (n = 104,108

Table 5. Extrapolated Number of Nonfatal Injuries Related to Construction, Maintenance, and Repair Activities for Mine Operators and Contractors by Major Commodity Group (n = 103,649).

Table 6. Extrapolated Number of Nonfatal Injuries Related to Construction, Maintenance, and Repair Activities for Mine Operators and Contractors by Type of Operation (n = 103,649).

Table 7. Extrapolated Number of Nonfatal Injuries Related to Construction, Maintenance, and Repair for Mine Operators and Contractors by Degree of Injury (n = 95,958).

Frequency Distribution Tables for a Mine, Accident, Injury, and Illness Database Sample Dataset (n = 21,024)

Table 1. Observed Number of Injuries Related to Construction, Maintenance, and Repair Activities for Mine Operators and Contractors by Major Commodity Group in Sample Dataset (n = 21,024).

Operators and Contractors by Major Commodity	CMR Related Activities		All Other Activities	
	Number	Percent	Number	Percent
Operators	5,336	39.0	8,338	61.0
Coal	1,778	37.1	3,015	62.9
Metal	985	37.4	1,652	62.6
Nonmetal	714	36.6	1,238	63.4
Stone	849	39.6	1,297	60.4
Sand & Gravel	1,010	47.0	1,136	53.0
Contractors	2,872	39.1	4,478	60.9
Coal	1,253	37.6	2,080	62.4
Metal	877	40.2	1,304	59.8
Nonmetal	192	37.2	324	62.8
Stone	501	41.2	714	58.8
Sand & Gravel	49	46.7	56	53.3

(**Note**: Numbers and percents are not to be extrapolated to entire mining population.)

Table 2. Observed Number of Injuries Related to Construction, Maintenance, and Repair Activities for Mine Operators and Contractors by Type of Operation in Sample Dataset (n = 21,024).

Operators and Contractors by Type of Operation	CMR Related Activities		All Other Activities	
	Number	Percent	Number	Percent
Operators	5,336	39.0	8,338	61.0
Underground Operation	652	27.6	1,712	72.4
Surface at Underground	1,119	36.0	1,991	64.0
Surface	1,279	42.8	1,712	57.2
Auger	45	37.5	75	62.5
Culm Banks	80	43.5	104	56.5
Dredge	764	45.7	909	54.3
Other Surface	53	41.4	75	58.6
Independent Shops or Yards	232	53.7	200	46.3
Mill or Preparation Plant	1,067	45.8	1,262	54.2
Office	45	13.1	298	86.9
Contractors	2,872	39.1	4,478	60.9
Underground Operation	379	25.9	1,085	74.1
Surface at Underground	202	36.7	349	63.3
Surface	1,304	43.2	1,716	56.8
Auger	8	24.2	25	75.8
Culm Banks	7	50.0	7	50.0
Dredge	5	38.5	8	61.5
Other Surface	4	30.8	9	69.2
Independent Shops or Yards	5	27.8	13	72.2
Mill or Preparation Plant	952	44.4	1,193	55.6
Office	6	7.6	73	92.4

(**Note**: Numbers and percents are not to be extrapolated to entire mining population.)

Extrapolated Estimates for All Injuries 1993-97 (n=104,108): Tables for the Mine, Accident, Injury, and Illness Database

Table 3. Extrapolated Number of Injuries Related to Construction, Maintenance, and Repair Activities for Mine Operators and Contractors by Major Commodity Group (n = 104,108).

Operators and Contractors by Major Commodity	CMR Related Activities		All Other Activities	
	Number	Percent	Number	Percent
Operators	36,772	38.0%	59,986	62.0
Coal	14,019	31.1%	31,034	68.9%
Metal	5,197	40.0%	7,787	60.0%
Nonmetal	2,467	37.9%	4,040	62.1%
Stone	10,849	46.0%	12,737	54.0%
Sand & Gravel	4,240	49.1%	4,389	50.9%
Contractors	2,872	39.1%	4,478	60.9%
Coal	1,253	37.6%	2,080	62.4%
Metal	877	40.2%	1304	59.8%
Nonmetal	192	37.2%	324	62.8%
Stone	501	41.2%	714	58.8%
Sand & Gravel	49	46.7%	56	53.3%

(**Note**: Table 3 contains the estimated number of injuries related to construction, maintenance, and repair activities for mine operators and contractors by major commodity and the type of operation. Percent of injuries for each type of operation is given as a function of the major commodities. Percent of injuries in each major commodity is given as a function of either all operator or contractor injuries.)

Table 4. Extrapolated Number of Injuries Related to Construction, Maintenance, and Repair Activities for Mine Operators and Contractors by Type of Operation (n = 104,108).

Operators and Contractors by Type of Operation	CMR Related Activities		All Other Activities	
	Number	Percent	Number	Percent
Operators	36,772	35.3%	59,986	57.6%
Underground Operation	9,598	26.4%	26,721	73.6%
Surface at Underground	1,119	36.0%	1,991	64.0%
Surface	12,582	44.0%	15,982	56.0%
Auger	45	37.5%	75	62.5%
Culm Banks	80	43.5%	104	56.5%
Dredge	764	45.7%	909	54.3%
Other Surface	53	41.4%	75	58.6%
Independent Shops or Yards	232	53.7%	200	46.3%
Mill or Preparation Plant	12,254	47.3%	13,631	52.7%
Office	45	13.1%	298	86.9%
Contractors	2,872	2.8%	4,478	4.3%
Underground Operation	379	25.9%	1,085	74.1%
Surface at Underground	202	36.7%	349	63.3%
Surface	1,304	43.2%	1,716	56.8%
Auger	8	24.2%	25	75.8%
Culm Banks	7	50.0%	7	50.0%
Dredge	5	38.5%	8	61.5%
Other Surface	4	30.8%	9	69.2%
Independent Shops or Yards	5	27.8%	13	72.2%
Mill or Preparation Plant	952	44.4%	1,193	55.6%
Office	6	7.6%	73	92.4%

Extrapolated Estimates for Nonfatal Injuries 1993-97 (n=103,649): Tables for the Mine, Accident, Injury, and Illness Database

Table 5. Extrapolated Number of Nonfatal Injuries Related to Construction, Maintenance, and Repair Activities for Mine Operators and Contractors by Major Commodity Group (n = 103,649).

Operators and Contractors by Major Commodity	CMR Related Activities		All Other Activities	
	Number	Percent	Number	Percent
Operators	36,667	38.0%	59,734	62.0%
Coal	13,967	31.1%	30,916	68.9%
Metal	5,189	40.1%	7,753	59.9%
Nonmetal	2,458	37.9%	4,032	62.1%
Stone	10,826	46.1%	12,677	53.9%
Sand & Gravel	4,227	49.2%	4,356	50.8%
Contractors	2,837	39.1%	4,411	60.9%
Coal	1,240	37.6%	2,056	62.4%
Metal	871	40.2%	1,293	59.8%
Nonmetal	186	36.6%	322	63.4%
Stone	494	41.8%	688	58.2%
Sand & Gravel	43	45.3%	52	54.7%

(**Note**: Table 5 contains the estimated number of injuries related to construction, maintenance, and repair activities for mine operators and contractors by major commodity and the type of operation. Percent of injuries for each type of operation is given as a function of the major commodities. Percent of injuries in each major commodity is given as a function of either all operator or contractor.)

Table 6. Extrapolated Number of Nonfatal Injuries Related to Construction, Maintenance, and Repair Activities for Mine Operators and Contractors by Type of Operation (n = 103,649).

Operators and Contractors by Type of Operation	CMR Related Activities		All Other Activities	
	Number	Percent	Number	Percent
Operators	36,667	38.0%	59,734	62.0%
Underground Operation	9,560	26.4%	26,603	73.6%
Surface at Underground	1,115	36.0%	1,980	64.0%
Surface	12,545	44.1%	15,888	55.9%
Auger	44	37.0%	75	63.0%
Culm Banks	79	43.2%	104	56.8%
Dredge	761	45.8%	900	54.2%
Other Surface	53	41.4%	75	58.6%
Independent Shops or Yards	232	53.7%	200	46.3%
Mill or Preparation Plant	12,233	47.3%	13,611	52.7%
Office	45	13.1%	298	86.9%
Contractors	2,837	39.1%	4,411	60.9%
Underground Operation	377	25.8%	1,082	74.2%
Surface at Underground	199	36.6%	345	63.4%
Surface	1,283	43.4%	1,676	56.6%
Auger	8	25.0%	24	75.0%
Culm Banks	7	50.0%	7	50.0%
Dredge	5	41.7%	7	58.3%
Other Surface	3	25.0%	9	75.0%
Independent Shops or Yards	5	29.4%	12	70.6%
Mill or Preparation Plant	944	44.5%	1175	55.5%
Office	6	7.6%	73	92.4%

Table 7. Extrapolated Number of Nonfatal Injuries Related to Construction, Maintenance, and Repair for Mine Operators and Contractors by Degree of Injury (n = 95,958).

Degree of Injury by Operators and Contractors	CMR Related Activities		All Other Activities	
	Number of Injuries	Average Days Lost	Number of Injuries	Average Days Lost
Operators	**34,408**	**26**	**54,828**	**31**
(2) Permanent Disability	511	24	574	39
(3) Days away from work only	12,626	27	28,697	34
(4) Days away & restricted activity	1,753	26	3,481	28
(5) Days of restricted activity only	3,675	-	6,144	-
(6) Injuries w/o death, days away, or restricted activity	15,843	-	15,932	-
Contractors	**2,681**	**25**	**4,041**	**28**
(2) Permanent Disability	51	21	68	26
(3) Days away from work only	1,064	26	2,014	29
(4) Days away & restricted activity	134	18	288	18
(5) Days of restricted activity only	230	-	412	-
(6) Injuries w/o death, days away, or restricted activity	1,202	-	1,259	-

OBSERVATIONS AND CONCLUSION

The CMR injury rates for operators and contractors were similar. Thirty-nine percent of all injuries were attributed to CMR activities for each group. The difference between the groups was found in the commodity. Contractor employee CMR-related injuries were highest in coal and metal, with sand and gravel the lowest. For operator employees the CMR-related injuries were highest in coal and sand and gravel.

Extrapolated numbers indicated that there were a substantial number of injuries over the five-year period - 39,644 - attributed to CMR-related activities. This finding documents the importance of the issue.

Overall 39% of the sample narrative descriptions were attributed to CMR activities. This is a significant finding for an industry that has focused much of their health and safety training attention on extraction and production.

Partly in response to this data, the Pittsburgh Research Laboratory, NIOSH has developed a Construction, Maintenance, and Repair Training Program (4) (5). The exercise utilizes 3-D slides and depicts various CMR work activities in degraded (hazy, muted, less than clear) scenes. (6) The use of degraded visual materials has been shown to improve miner's hazard recognition abilities (7). The program focuses on specific activities and behaviors relating to CMR at a sand and gravel surface operation.

http://www.cdc.gov/niosh/mining/training/default.htm

The data presented supports a need to incorporate construction, maintenance, and repair activities in mine safety training. Further analysis of the data will lead to specific interventions in various commodities and at different locations.

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[1]*This paper is a presentation, in part, of the data in the final report "Miner Injuries Related to Construction, Maintenance, and Repair Activities..." by Battelle Centers for Public Health Research and Evaluation, Seattle, Washington under Contract No. 200-94-2837, Work Assignment No. 2837-23 prepared for CDC, NIOSH by Diana Escheverra, Ph.D., Stephen Wilkins, and Kelly Bowman; under NIOSH Project Officer Chip Lehman, Ph.D. and Larry Layne, Technical Officer, August, 1999.*

THE PROMISE OF E-GOVERNMENT

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INTRODUCTION

One of the primary roles of the U.S. Mine Safety and Health Administration (MSHA), is to deliver accurate, timely information to the mining community in order to prevent accidents, injuries and fatalities. The importance of a shared knowledge base was vividly illustrated on July 28, 2002 when 9 miners were rescued from the Quecreek mine in Somerset, Pennsylvania.

There were many factors, which resulted in a successful rescue rather than a tragedy at Quecreek. But perhaps the biggest key to success was the combined knowledge, information-sharing and training among the engineers, drilling team, medical personnel and trapped miners.

In the 77 hours that the miners were trapped, dozens of life and death decisions had to be made, including: where to drill the initial air hole, where to get a second drill bit, how quickly to pump out the water, whether or not to turn off the compressed air, among others.

In the end, the miners were saved by knowledgeable people making good decisions based on timely and accurate information.

It is within the spirit of Quecreek that I am proud to represent MSHA today to address the 33rd Annual Institute on Mining Health, Safety and Research. And it is more than a little ironic that the title of this workshop is "The Promise of E-Government", because at its core, E-Government is about the timely sharing of information between the federal government and the general public.

ABOUT E-GOV

Electronic Government (or E-Gov) is a major Presidential initiative to transform the federal government from a slow, paper-based bureaucracy into an electronic, responsive entity for the 21st Century.

The goal of E-Gov is to make the federal government more accessible, efficient and reliable by using available computer technology. To the extent possible, the public should be able to file applications, review regulatory materials, make payments and access public data through their computers and web browsers.

Under E-Gov, federal agencies are required to evaluate and, where feasible, update the methods in which they provide services to the public, other federal agencies, and their employees. In addition to making information available, agencies should also use technology to expand training programs, to identify and adopt best practices, and to partner with the research community.

One of the main thrusts of the E-Gov initiative was the 1998 passage of The Government Paperwork Elimination Act (GPEA). Under GPEA, Federal Executive agencies are required, by October 21, 2003, to convert most paper-based transactions to electronic format. To facilitate this process, Congress and the President also enacted E-Sign, making electronic signatures as valid as pen and paper signatures in a court of law.

The federal government has also established a web portal called FirstGov. This portal is designed to be the first electronic point of entry for the general public to access all areas of the government. At this site, users will be able to access government services, review legislation, submit applications for federal programs, pay taxes and access government data. Some of the forms citizens can access through the Web site include tax forms, social security forms and passport applications.

MSHA AND E-GOV

MSHA has always recognized the relationship between good information and safety. And, as mentioned above, the Quecreek accident reinforced to everyone at MSHA that good information can save lives.

MSHA's Assistant Secretary Dave Lauriski fully embraces E-Gov and has issued a challenge to the employees to transform the agency into an efficient, effective, customer-focused agency. In the words of the Assistant Secretary, when people interact with MSHA, they should receive the same timely, quality service that they demand from any private sector business. Every form used, every study conducted and every piece of data collected should be available to citizens and businesses through the Internet.

MSHA has developed a broad-based strategy to comply with E-Gov and to make it easier for customers to interact electronically with MSHA. The proposed MSHA E-Gov Initiative consists of the following strategies:

Move Paper-Based Forms on to the Web

MSHA has over 80 public-use forms and record-keeping requirements that can be made available electronically. There are two ways to make the forms available to the general public: a) provide the forms in a format which can be downloaded, printed out and manually submitted by the user, and b) provide data entry screens where users can actually submit the data electronically. MSHA is working to implement both of these alternatives. All of MSHA's most frequently used forms are currently available for downloading, and MSHA is in the early stages of developing online submissions for most of its transactions.

Improve Security

In order for customers to feel confident when submitting sensitive information or paying bills online, MSHA must develop secure methods for customer interactions. MSHA is investigating various methodologies such as Public Key Infrastructure (PKI) and Virtual Private Networks (VPN) to ensure that sensitive information remains protected during transmission and storage.

Create Internet Portals for the Mining Community

MSHA intends to begin creating individualized, customized portals, which will allow customers to view the information they care most about. For example, many mining companies want to see their individual production or accident reports and to be able to compare them to the industry in general. Researchers are interested in aggregated safety data that allows them to track trends. These portals may even allow individuals to customize their portal pages to get the specific, recurring information they want in a timely fashion.

Implement a Data Warehouse

MSHA currently provides a data warehouse, which allows individuals to submit queries to generate reports. This warehouse was designed for internal use and has limitations for the general public. As a result, MSHA is in the process of revamping the data warehouse in order to meet the public's desire to use MSHA data in trend analyses. This support will provide the mining community with the opportunity to improve their own safety and health monitoring activities.

Develop Electronic Document Management

MSHA currently interacts with the public through a number of highly manual business methods, particularly in the area of processing paperwork and forms. A specific example includes the processing of quarterly employment and production statistics from forms that are mailed or faxed to MSHA. This high volume process is prone to error, and causes significant delays in information access due to the time it takes to enter the information. MSHA is working on a document management system capable of handling paper-based submissions as well as electronically–based submissions such as e-mail. This system should allow MSHA to expedite retrieval of documents and analyze data upon receipt.

This initiative will also address the current document management system utilized by MSHA's Directorate of Technical Support. This system contains approximately 700,000 images of manufacturer's drawings, equipment designs, and technical data on various products used in mining.

Redesign MSHA's Website

MSHA's website has grown over the last few years from a few pages to more than 20,000 pages today. The website was initially designed from MSHA's perspective, offering visitors information that was important to MSHA, such as organizational charts and regulatory information. In order to ensure that the Website reflects the needs and wishes of our customers, MSHA has been reaching out to the mining industry to identify the most important information *from our stakeholders' perspective* and then feature that information in an easy-to-use, interactive way.

Improve and Expand MSHA's Network

As electronic interactions with the public increase, MSHA will be required to expand and upgrade our network architecture. MSHA is currently in the process of extending the network to all of its field offices around the country so that each inspector can communicate electronically. MSHA is also improving the network architecture and expanding broadband to make the system more stable and robust for both the public and MSHA employees.

Streamline the Databases

In order for E-Gov to succeed, MSHA must restructure its major applications – a number of 25 year-old mainframe systems using out-dated technology. MSHA is in the second year of a long-term process of consolidating its mainframe legacy systems into one common platform - one MSHA Standard Information System (MSIS).

HOW THE MINING INDUSTRY WILL BENEFIT FROM E-GOV

MSHA's E-Gov initiative will make it easier for stakeholders to interact with MSHA and to make public information available through the web. Some of the benefits of E-Gov for the mining community include:

Immediate Access to Data

MSHA stakeholders will be able to access up-to-date information related to accidents, injuries, production, health samples and any other public information currently collected. The data will be available though custom, user-

defined reports and queries as well as through standard reports.

Sharing of Best Practices

The mining community will be able to share information on best practices and learn about the latest mine safety research with anyone around the world. Interactive newsgroups will serve to create virtual communities with similar interests.

Customized Information

Each user can have a customized page or portal to access information specific to particular mining operations and will be able to compare their operations with similar mines around the country.

Online Filing and Payment

Those who wish to will be able to fill out required forms and reports online. This will significantly reduce the paperwork burden and streamline the process. It is MSHA's goal to provide the mining community the option to submit any form electronically that must currently be mailed. Eventually, companies will also be able to pay for equipment approval fees, or assessed penalties - or contest others - online.

Electronic Data Exchange

Mining companies will be able to submit data from company files in native format directly into MSHA's database and, conversely, MSHA can update each company database at the end of each month through data exchange.

Interactive Training

As MSHA expands and improves its website and network, it will also develop more online training materials. The mining community will be able to access training over the Internet using streaming media and broadband connections. This will make certain types of training and certifications more cost-effective, particularly for smaller companies.

CONCLUSION

E-Gov has the potential to make government much more accessible to the general public than it has been in the past.

MSHA is aggressively moving forward to implement E-Gov through a broad-based strategy, which will be implemented in stages over the next few years.

The mining community will be able to gain immediate access to MSHA's public information. They will also be able to electronically share information, submit reports, receive online training, pay assessed penalties and learn about best mining practices.

MSHA is fully committed to E-Gov, not just because it will make it easier for the mining community to do business with MSHA, but more importantly, because it has the potential to improve the health and safety of our nation's miners.

MINE EMERGENCY RESPONSE COMMAND CENTER TRAINING USING COMPUTER SIMULATION

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ABSTRACT

As mines become safer and major disasters fewer, the number of experienced emergency responders is decreasing. This decrease will create a gap in response expertise which could have serious ramifications during future mine disasters. While working toward safety goals which may make emergency response obsolete, it would be reckless not to acknowledge that the potential for disaster still exists and that the protection of miners in such circumstances must remain a priority. The Mine Emergency Response Interactive Training Simulation (MERITS) is a computerized mine emergency simulation that meets a variety of needs. It allows personnel in leadership positions to test their knowledge and skill. Groups of individuals composed of representatives from mining companies, labor, and government agencies can practice working together during the simulated mine emergency much in the same way an actual emergency would require. An individual could also run the program to enhance his or her response skills. With this training tool, responders will be able to learn from their mistakes before facing situations with potentially catastrophic consequences. This paper discusses MERITS and its use in providing command center training.

INTRODUCTION

When the World Trade Center Towers were destroyed on September 11, 2001, the need for emergency response readiness was tragically brought to everyone's attention. Less than two weeks later, on September 23, the mining industry was dealt a blow when thirteen miners died in an explosion at an underground coal mine in Alabama. These experiences show that while working toward prevention of catastrophic events is important, we must also prepare to respond when the unthinkable happens.

Major mine emergencies have become relatively rare events in the United States and there has been a corresponding decrease in the number of people who have hands-on response experience. This gap in expertise could have serious consequences during future responses. Managers who are responsible for day-to-day operations may suddenly be called upon to act as command center leaders with little or no previous experience in that role. Their lack of knowledge and skills could put in danger the workers who were present when the emergency occurred and also those called upon to respond. The goal of MERITS is to better prepare managers and government and labor representatives for mine emergency response leadership roles. This paper: 1) presents the

rationale for development of MERITS, 2) discusses how the simulation differs from other computer-based training, 3) illustrates basic components of the interface, and 4) presents results from field tests of the exercise.

BACKGROUND

In the early 1990's, researchers from the former Bureau of Mines conducted extensive interviews with 30 individuals who were nationally recognized experts in the area of emergency response. These experts were asked how they would train future mine emergency responders (Brnich, Mallett, and Vaught 1997a, 1997b). While responses provided by interviewees varied, nine of them believed that some form of interactive simulated response training would be the best way to train responders. Three methods of simulation were discussed: mock disasters, MERD exercises, and tabletop exercises. Nine veterans also suggested that future responders be trained in mine emergency response planning.

Ten veterans talked about the need to adequately train mine or corporate management personnel in emergency response procedures. As one interviewee indicated, managers will be the ones who will be playing major roles in the decision making process at the command center. In addition to training management, five veteran responders said that enforcement personnel should be thoroughly trained in emergency response. As mentioned by one interviewee, more and improved training for these individuals will enhance their ability to respond to a mine emergency when it occurs.

Why is the issue of training future mine emergency responders so important? The answer to this question can be found in one veteran's comment:

> *... a lot of people have come and gone since 1969. And we're having less problems. So, in the next 10 to 15 years, there's just going to be a hand-full of people that have had any experience. Cause, we don't send people to go to the [mine emergencies] that we have. There's no way to get that on-hand experience other than to be there.*

In short, mine emergency response veterans clearly indicated that training response personnel is paramount, if mines intend to be prepared to handle a major emergency should it occur.

COMMAND CENTER TRAINING

Emergency response is sometimes given a low priority in training planning because catastrophic events occur infrequently. While there are extensive training requirements for mine rescue team members, there is no mandated training for command center leaders. Many managers have little or no experience in dealing with large-scale mine emergencies. Since no one wants to believe a disaster will happen, day-to-day job pressures make taking time for emergency response training seem like a luxury for another day. Unfortunately, that day may not come before the emergency happens.

Command center training is available through the Mine Safety and Health Administration (MSHA) and other sources. Frequently training is the form of a full-scale simulation and presents the complexity of a major response to the trainees. It gives trainees the needed view of the overall response, but is resource-intensive to conduct. MSHA's Mine Emergency Response Development (MERD) training allows participants to act out various response roles. This type of hands-on experience is excellent command center training for those chosen to fulfill those roles, but is less effective, in terms of command center preparation, for those playing other roles.

Another form of enhanced command center training is in the form of a mock mine disaster. Like MERDs, mock disasters are role play exercises designed to present a realistic mine emergency scenario. However, unlike MERDs, they use actual mine facilities and involve mine

personnel in their assigned roles at the operation. However, staging these events requires significant time and the devotion of considerable resources from the mine and other organizations. For personnel at small, remotely located operations, full-scale mock drills and even MERDs may seem out of reach.

MERITS augments existing command center preparation with a training simulation that can be delivered at any location with basic computer equipment and an Internet connection. Many, if not most, mine sites have such equipment. If nothing else, most mine sites are within a reasonable distance of a public or private facility such as vocational technical school or community college with the required tools. Even the most remote mining sites can be equipped with a lap top computer and a telephone connection. Aside from the computer equipment, MERITS requires few other resources. While a group of three to five participants is recommended, a successful training session can be run even for one individual.

During the session, all trainees are part of the simulated command center and receive the same experience. MERITS can be used to give select individuals a basic understanding of command center functions before they are placed in leadership roles during a MERD or mock drill. It could also be used to allow participants of other types of training, who were not in command center roles, an opportunity to have that experience. MERITS has also proven to be an effective way to give mine rescue team members the "big picture" of large-scale response activities. Knowledgeable trainers can tailor MERITS for the novice and for the veteran responder. In all cases, a trainer competent in the subject matter should be available to trainees.

HOW MERITS DIFFERS FROM OTHER COMPUTER-BASED TRAINING

Computer instruction is the process in which a computer is used to present information to the trainee. Computer-based training, or CBT, is generally used to describe the application of computer instruction to various training settings, including training in the workplace. CBT offers several advantages over other types of instructional methods: 1) it offers learning in the classroom but has the potential for learning in remote locations; 2) it can be standardized, customized, or changed as necessary to meet changing needs; 3) it is cost-effective in that large groups of trainees are not required to make up a class; and 4) it is convenient since trainees can attend training at their own workplace and work at their own pace (Anonymous, 1998; Charles, Black, and Murphy, 1992; Dennis, 1994; Drape, 1994; Guilar, 1994; Shaw, 1992). Computer-based training also generates positive attitudes and enjoyable experiences among trainees (Kulik & Kulik, 1991; Shaw, 1992).

The training objectives of MERITS are meant to enhance the decision-making performance of command center personnel during mine emergencies. This goal is achieved through the use of computer-based simulation problems. Potential users will ask how well an electronic emergency response will prepare them for the real thing. This is really a question of validity, and must be answered by beginning with the use of computers as teaching and assessment instruments.

If one draws a Venn diagram of computers, simulations, and instruction, the result might take the form of Figure 1 (Leonard, 2002). That is because computers are used for much more than simulation, even when they are employed for instructional purposes, and also because computer simulations are not always used to teach. Thus, actual instruction is only a small

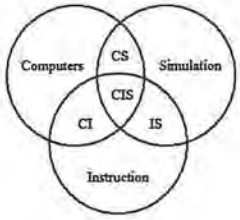

Figure 1. Integrated relationships of computers, simulations, and instruction.

part of the potential uses for either computers or simulations. A brief discussion of some salient issues relating to each overlapping segment will put the diagram into better perspective.

CS - Computer simulations do not necessarily instruct, any more than life experiences necessarily teach us anything.
Instead, they allow one to observe the playing out of certain hypothetical events, such as a drought on the farm, and may, in the case of expert systems, advise us on how to cope with the situation. While these types of tools are of value, they are not much use as stand-alone teaching devices. Not until an instruction plan has been incorporated into the simulation does structured learning and evaluation take place.

CI - In many instances, where computing and instructional methods overlap, computers are used not to simulate events, rather, they serve to deliver instructional material for individualized learning. Often they are electronic page turners, carefully metering stimulus and response, measuring out facts and figures in acceptable doses. While there is nothing wrong with this type of instruction and evaluation (or this use of computers), it is better suited to some purposes, e.g., teaching maintenance SOPs, than others, such as emergency response activities.

IS - Instructional simulations take many forms and all can provide powerful vicarious learning experiences that may better prepare workers to deal with actual events. Training of mine rescue teams, military personnel, and fire fighters routinely makes use of both full-scale field simulations and so-called paper and pencil (or "tabletop") exercises. Unlike case study reviews, instructional simulations do not present the outcome of an emergency as a means for evaluating individual decisions made during the course of the event. Rather, the simulation problem unfolds and requires decisions among alternatives to be made with incomplete information similar to the process involved in an actual emergency. Instructional simulations have an interesting advantage over participation in actual emergencies: They can provide the learner with an overall perspective on key relationships and interactions among the human players, physical factors, and equipment, as well as revealing both the predictable and capricious events that are always part of any emergency. This type of overall comprehension of the "problem space" is thought to result in greater wisdom on the part of the participant. In aviation circles, instructional simulations are used to teach what is often referred to as "air wiseness" with promising results [Flathers, et al., 1982; Giffin and Rockwell, 1984].

CIS - MERITS is in the smallest subset of the diagram's intersection, because it is a computer simulation that is intended to deliver quality instruction. Quality begins with content. As Gibbons and Fairweather [1998] note, "In order to be used for instruction, a simulation has to be integrated into a larger instructional plan, and in many cases it has to be complemented with additional instructional features which are not part of the simulated model itself." Additionally, however, the package must do the following: 1) allow trainees to construct knowledge for themselves from the elements of the simulation; 2) require trainees to engage heavily in forward planning and problem solving; and 3) encourage trainee initiative. In other words, the simulation must be grounded in lived experience and have specific performance objectives that are explicitly stated.

DESCRIPTION OF MERITS

Modeled after training simulations developed for other industries (e.g. to address nuclear accidents, chemical spills, evacuations), MERITS simulates underground and surface events related to the disaster. It exposes the user to events that typically occur during a mine emergency such as lack of information and miscommunication. It also presents trainees with issues that must be addressed such as making provisions for briefing news media and victims' families, ordering needed supplies, interfacing with enforcement agencies, and housing mine rescue teams. The outcome of the scenario will be determined by the users' decisions and their emergency response plans.

MERITS presents an underground mine emergency scenario that develops over time, with a continual unfolding of points at which the emergency managers must either initiate decision alternatives or do nothing. The decisions will of necessity be like those that individuals or groups have employed (or failed to employ) in actual emergency situations. Some will be good alternatives and some, while possible, may not be effective (or may even be harmful). Completion of this exercise will result in a hard-copy record of the individual or group's decision choices. A performance score is based upon the pattern of responses, and can be registered in terms of percent correct performance (mastery).

While individuals are working the simulation problem, they also receive feedback about what impact the chosen alternative has had upon the situation. Thus, the exercise teaches by reinforcing good decisions, concepts, and strategy, while providing a basis for remediating incorrect thinking. Accompanying study notes, reviewed and discussed following problem administration, further elaborate the information and strategies that are exercise objectives, and help to situate this information in the specific experience of those individuals who work the simulation.

Characteristics of the Simulated Mine

The MERITS simulation is set at a small underground coal mine called Bottleneck No. 1. A small mine site was chosen for the first MERITS scenario because it is appropriate for a wide range of trainees. Many people work at fairly small operations, and those who do not might be called to assist in a response at one. Bottleneck No. 1 mine employs 56 workers and has two daily production shifts. Maintenance is conducted on the midnight shift. Coal is mined using continuous mining practice in two working sections. One section is on development and one is on retreat. A spare, idle section is also available for production. Equipment on all three sections includes one continuous miner, one twin-boom roof bolter, two shuttle cars, and a battery scoop tractor. Coal is transported from working sections on 36- and 42-inch conveyor belt from sections to the outside and dumped on the raw coal pile near the portal. The coal is then trucked to the preparation plant at a sister mine located four miles away. The corporate offices are also at the sister mine.

Trainees are given information about the mine's current status. A mine map includes details such as air direction and the locations of power centers, belt, track, mine phones, and SCSR caches. Mine documents such as pre-shift and on-shift reports and roof and ventilation plans are available for trainees to review. A personnel list provides the name, job title, certifications, and the usual shift of each employee. A tag board can be checked to determine who is underground at any given time.

Bottleneck No. 1 Mine has an extensive emergency response plan (ERP). This plan was developed with the assistance of personnel from the Pennsylvania Bureau of Deep Mine Safety. These safety professionals have assisted many small mines in development of site specific plans. The plan for Bottleneck No. 1 was developed in the same way as those created for mines across the state. The first part of the plan includes items such as a call-out roster and emergency duty assignments. Trainees may or

may not choose to follow these guidelines as the situation evolves. The second part of the plan is an extensive list of providers of services and supplies. The simulation recognizes the phone numbers that are given in the plan so trainees can contact the simulated individuals and businesses for assistance during the MERITS session.

The trainees serve in the role as superintendent of Bottleneck No. 1 Mine. The stage is set for the simulation to begin with the following information about the day of the event:

As you drove to work on Route 350 this morning, you noticed the recent heavy rains had caused a slide that covered part of the right-hand lane. A DOT crew was there getting ready to set up warning barrels. You went around, and within a mile came to the mine access road.

Around 7:30 a.m. you pulled into the small parking lot in front of your office and entered the building. Since then you've been doing routine paperwork.

It is around 9:30 a.m. As the simulation starts, routine conversations are heard over the mine pager phone. The trainee can look at various mine records including pre-shift and on-shift reports, fan and barometric pressure reports, and other information. The mine clerk comes in and gives the latest time sheets and vacation requests for review and returns to her office. From that point on, what happens or does not happen is related to the actions or inaction of the trainee. Figure 2 shows trainees and a trainers engaged in a MERITS session.

Interacting with the Computer Program

The computer interface is organized to serve as an interactive work space where trainees engage with the simulation. It consists of a number of web pages and methods for navigating them. A picture of a typical MERITS screen is shown in Figure 3. Most of the screen is the data area where information or tools selected by the trainee are provided. A toolbar is

Figure 2. Trainers and trainees during a MERITS session.

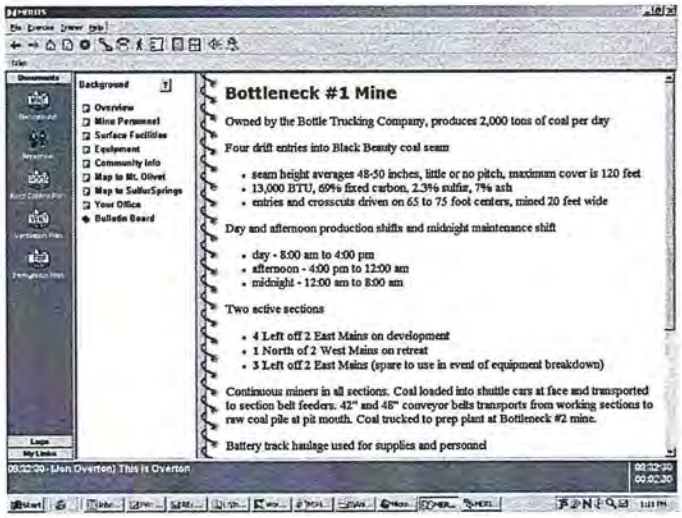

Figure 3. Typical MERITS screen.

found across the top of the screen and the reference bars are located down the left side of the screen. The bars contain icons that can be selected to move among the available references, logs and tools. Trainees select icons on the left toolbar to display reference material and logs that are needed to analyze and resolve the emergency situation. The currently-selected reference or log appears in the data area of the screen. Tools that can be used to take actions (such as issuing orders to resolve the emergency situation) are provided in the top toolbar. When a tool is selected, a dialog box for that tool "pops up" over the data area of the screen requesting further information. Figure 4 shows the

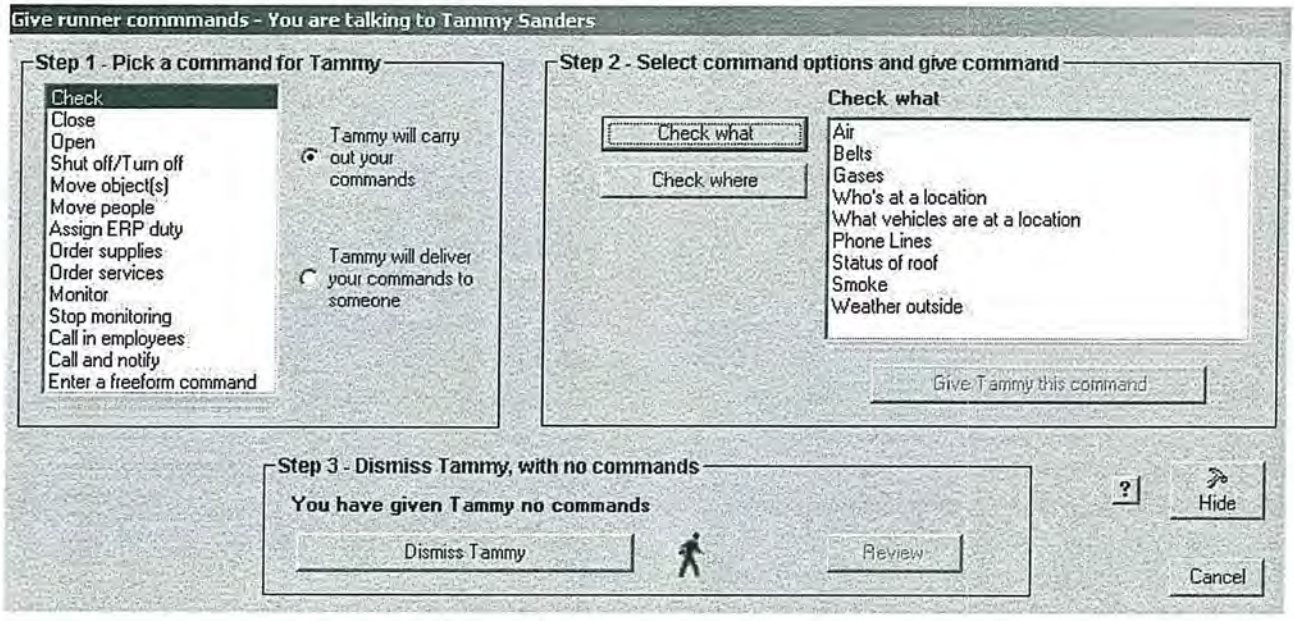

Figure 4. Screen for issuing a command to a runner.

command box that "pops up" after the runner tool is selected.

After the simulation has started there are a number of tools, reports and communication devices that a trainee can access. These provide information or support interaction with the simulation. The following information can be referenced at any point during the simulation.

- General Mine and Community Information
- Roof Control Plan
- Ventilation System, Methane and Dust Control Plan
- Bulletin Board Postings
- Personnel List
- Emergency Response Plan
- Shift Reports
- Underground Tag Board
- Supply List

The interface includes tools that help trainees progress through the simulation. These tools can be accessed at any point during the simulation and include:

- Mine pager phone
- Telephone
- Runner(s) to do tasks and carry messages
- Mine map
- Clock showing simulation time
- Repeat last audio and visual communication
- A notebook to record trainee notes and reports from simulated miners
- Log that can be assigned to the runner to keep
- A log used to construct briefings/reports

Trainees can refer to help files for questions regarding the use of any communication devices or tools. These help files are accessible at any time during the MERITS simulation.

HOW MERITS IS EVALUATED

As with any training intervention, evaluation is critical to ensure its success. People typically think evaluation in terms of standardized norm referenced tests. The developers of these types of instruments attempt to construct exams that are restricted (not circulated) because they wish to measure performance with the same instrument in the future. Efforts are made to prevent feedback

and learning during administration in order to avoid confounding an estimate of a person's ability with what he or she may have learned from taking the test. Such instruments are designed to rank persons by ability levels, but obviously not to maximize the learning experience.

MERITS does not evaluate trainees from a norm-referenced perspective. Instead, MERITS is criterion-referenced. Performance on this type of test is not defined by rank ordering a person's score according to the distribution of scores in some normative group, but is instead described by mastery of knowledge, skills, and strategies included in the exercise (Cole, 1994). If well constructed, such instruments are known to provide valid evaluations of what test takers know how to perform well or not so well. When individuals' scores fall below mastery levels, the performance data from these exercises are used to target areas that need further instruction. Criterion-referenced tests are also known to teach persons who complete them, and this is viewed as a proper outcome. In fact, criterion-referenced exercises is the method of choice for teaching and assessing critical skills and are widely used for this purpose. That is precisely the goal of MERITS.

The MERITS simulation focuses on specific performances in well-defined domains. Proper field-testing provides psychometric data on mental measurement properties of the exercise. At the same time, information is obtained to reveal skill areas in which the participants performed well and in which they performed poorly. Overall mastery levels can also be computed. This type of information can be used immediately to ensure that performance errors exhibited while working the simulation can be remediated by further instruction. Such corrective measures can help prevent these errors from occurring in actual emergencies. Aggregated data can also be used to compare the skill levels of groups who may have been trained: 1) by different persons; 2) using different methods; and/or 3) in different organizations (Cole, et al., 1988).

In summary, the MERITS simulation is clearly a training tool and was designed to be such. It is also a valuable evaluation tool that can reveal much about what different groups of participants know and do not know, as well as strengths and weakness in their logical decisions when they are faced with the predicaments involved in dealing with a mine emergency. This performance data can be used to improve training and policy. The military routinely uses similar simulation tasks to teach and evaluate the proficiency of individuals in specific areas, and to make changes in their training objectives and activities based on aggregated performance data. The same can be done in the mining industry.

VALIDITY OF MERITS

No matter how well designed a training simulation may seem, a critical question that must be answered is: "How well does the simulation prepare someone to cope in a real-world situation?" There is no group, including the military, that routinely conducts real-world validity studies of similar critical skills. Other groups who engage in good criterion-referenced skill training and evaluations do what has done with MERITS, that is, they go to great lengths to ensure that the simulation is grounded in significant real-world problems. Additionally, these groups enlist the assistance of experts in making judgments about the exercise's face validity. They then administer the simulation to experienced workers who have familiarity with the skills and performances involved. These persons are asked to rate the authenticity and value of the exercise, and their performance scores are recorded and analyzed.

It is important to ask participants if they: 1) could follow directions and comprehend the interface; 2) judge the simulation to be authentic; and 3) deem the exercise to be valuable in respect to its goal of improving their knowledge and learning. If a group rated these elements low, it should be clear that no matter what else was known about its properties, the

simulation would be invalid because it would not be accepted or judged worthwhile by the very audience it was designed for. Such information is critical, and certainly an appropriate part of the face and content validity estimates for such exercises.

We may never know the "ultimate" validity of MERITS. Based on field test results, we can be fairly sure, however, that it provides useful information and an opportunity to practice those critical cognitive skills that are needed for effective performance during emergency management. We can also be sure that little current training in this area addresses similar types of "soft" skills. It is almost certainly better to have faced these decision-making tasks initially in the context of a simulation than during an actual event. This is especially true if one's earlier learning is mainly a set of rigid protocols about how things should be done, with little awareness of how unforeseen predicaments and dilemmas cause those protocols to break down.

Field Test Experience

Initial field testing of MERITS was conducted with 27 individuals during eight full-day training sessions at four different locations in Colorado, Pennsylvania and West Virginia. These field tests benefited from the knowledge and experience of Pennsylvania mine inspection officials, representatives of the United Mine Workers of America, and private mine management, who all served as trainees for the MERITS training sessions.

Trainees self-reported an average of 20 years work experience in the mining industry. All trainees had participated in MERD training exercises and many had been involved in actual mine emergencies. Trainee evaluation of the MERITS program was based on responses to a series of statements regarding the simulation. Responses to each statement on the Likert Scale questionnaire could range from Very True, Very Useful, or Very Helpful to Not True, Not Useful, or Not Helpful. Table 1 presents trainees' responses to selected statements.

Subsequent to the initial field tests, MERITS was refined and retested during training sessions for individuals from state agencies, the UMWA, and private industry. Mining personnel from underground coal and underground stone mines participated and responded positively to the learning experience.

Table 1. Field test results.

Statement	Number responding	pct.
The simulation helped me know how to prepare for a real emergency.	26 "Very True or True"	96.4
The storyline for the simulation was realistic.	25 "Very True or True"	92.6
The simulation helped me learn how to better handle a real emergency.	27 "Very True or True"	100.0
I was not bored during the simulation.	27 "Very True or True"	100.0

Continued Training and Evaluation

MERITS researchers and industry and enforcement representatives have continued to work together to organize additional training sessions. At the request of the Pennsylvania Bureau of Deep Mine Safety, a series of training sessions was held at the agency's Ebensburg, PA mine rescue station for members of the state's mine rescue teams. A total of 21 individuals participated in MERITS training held in early 2001. As with the initial field tests, trainees evaluated MERITS by completing a Likert Scale questionnaire following the training session. The group of trainees reported 15.9 years of mining experience and all 21 had received mine rescue training.

Trainees' responses to selected statements are summarized in Table 2.

Table 2. Results from additional field tests.

Statement	Number responding	pct.
The simulation helped me know how to prepare for a real emergency.	21 "Very True or True"	100.0
The storyline for the simulation was realistic.	20 "Very True or True"	95.2
The simulation help me learn how to better handle a real emergency.	21 "Very True or True"	100.0
I was not bored during the simulation.	21 "Very True or True"	100.0

CONCLUSION

Since research and development of MERITS began in 1996, the simulation has been constructed, field-tested, and authenticated. Field test results indicate the simulation has strong face validity and is a useful tool for teaching important decision making skills to command center personnel. Through calendar year 2002, MERITS will continue to be introduced to the mining industry through several venues, including technology transfer seminars, conference presentations, and train-the-trainer sessions. A four-volume NIOSH Information Circular, documenting MERITS and its use in emergency response training will be completed in 2002. This multi-document set will include: 1) a general overview volume; 2) a trainer's manual on conducting a training session; 3) a software user's guide; and 4) a software documentation guide.

Based on field test and training session results, MERITS is a robust training tool for teaching critical mine emergency response decision making skills for command center personnel. Although the simulation is based on an emergency incident at an underground coal mine, MERITS could be adapted for other types of mining operations, including underground metal/nonmetal and surface mines, as well as a variety of different types of emergency scenarios. While MERITS is no longer a funded research initiative under NIOSH, the authors hope other interested parties will build upon work already completed to further develop MERITS.

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TRAINING EVALUATION PROCESS AND TOOLS

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One of the outcomes of the promulgation of 30 CFR, Part 46 has been increased awareness of the need to evaluate mine health and safety training. The new law explicitly cites knowledge of evaluation techniques as part of the definition of a competent trainer. It further encourages evaluation by including it as one of the required components of a training plan that can be implemented without MSHA review. With the attention given evaluation in Part 46, it is likely that mine trainers are also reviewing the evaluation requirements of Part 48. Under this law, task training must be evaluated. The question for many health and safety managers, resource personnel, and executives is how do they begin to evaluate their training program? To answer this question, they need to have an understanding of the theory and methodologies used in evaluation research. This paper will provide a background for understanding what evaluation is and the techniques that can be used to examine the effectiveness of a training program.

The term evaluation can be used to define multiple activities that result in a critical review. For purposes of this paper, evaluation is defined "as the process of determining the value and effectiveness of a learning program" (Clark, 1997). Value and effectiveness are subjective terms and they must be defined with standards set for each in an evaluation plan. The plan should answer the questions below which will be discussed in the following sections.

1 - What is the purpose of the evaluation?
2 - What will be measured?
3 - How comprehensive should the evaluation be?
4 - Who determines and oversees the evaluation?
5 - What is the source of the data and how will the data be collected and compiled?
6 - How should the data be analyzed and presented? (Clark, 1997)

An evaluation strategy addressing these questions should be created at the same time that the training is being developed. Incorporating an evaluation component into a training plan will help to ensure that the evaluation focuses on topics, practices, or skills that are desired results of the training and that data can be gathered at appropriate times before, during, and/or after training implementation. Even if the training program is being developed by a contractor or outside vendor, the contracting organization should be involved in this initial planning phase.

Purpose of the Evaluation

Just as a training program should have specific goals, the evaluation plan should also be based on explicit goals. Identifying evaluation goals should be completed by the organization before the training is designed and implemented. Specific goals that might be included in an evaluation plan can be determined by the following categories.

1 - Feedback- quality control to determine how learning outcomes link to initial training objectives.
2 - Control- assessing the training program in relationship to other organizational activities and to consider cost effectiveness.
3 - Intervention- to make changes to improve future training program implementation. (Blamey and Newby in Clark, 1997)

In mine safety and health training, one kind of feedback often needed is whether or not training is meeting the requirements of federal and state training regulations and policies. This goal should be stated and the specific rules to be met should be identified in the evaluation plan.

Another important determinant of the purpose of an evaluation is the audience who will be interested in the results. This could include trainers, trainees, managers, government officials, future employers of contract training firms, and others. Determining who will have access to the results and their needs should be part of the planning process. For annual refresher training, under Part 46, could include MSHA personnel and state mining officials who will want to see how the training plan and/or specific training activities meet legal requirement. Trainers will want results that can assist them as they plan future training sessions. Mine managers may want cost/benefit related information for future planning needs. On the other hand, do not include goals that are not of real interest to some specific party. If findings will not be used, it is not effective to put resources toward obtaining those results.

Evaluation Target

Evaluations can address multiple questions about a particular training program. In the late 1950's, Donald Kirkpatrick developed one framework that can help explain what can be learned by evaluation (Nichols, 2000). Over forty years later, Kirkpatrick's four levels are still used in discussions of training program assessments. Level l is the easiest and least resource intensive to conduct. Level 4 is the most difficult and expensive (Kirkpatrick, 2001, pp. 122-132). "As we move from level 1 to level 4, the evaluation process becomes more difficult and time-consuming, although it provides information of increasingly significant results." (Clark, 1997) Each level is briefly described in the table below. A discussion of how the levels could be defined for safety and health training follows in Table 1.

Level 1 – This is the most common kind of training evaluation. It frequently consists of post-training questionnaires asking for the trainees' opinions about course content and/or the instructor. It can include questions related to the class setting and other factors that could impact the effectiveness of training. This level of evaluation is particularly useful to trainers who are interested in improving future training sessions. It is also possible to determine outside variables that could be impacting training such as uncomfortable classrooms or unfamiliarity with training tools or methods. While questionnaires are often used to gather data regarding trainee reactions to training, it is not the only method to obtain this data. Other methods will be discussed in a later section. Level 1 will be included in most evaluation plans.

Level 2 – This level focuses on any change in knowledge or skill that can be attributed to training. This requires measuring the knowledge or skill before and after training. Additionally, any other factors that could have caused the change must be explored. The most rigorous study model requires testing two equal groups, then administering training to only one group, and finally retesting both groups. Assuming no outside influence has made the groups dissimilar during the training phase, any differences recorded between changes in performance of the untrained and trained groups would be attributed to training. In safety and health training it is sometimes not ethical or wise to withhold training from one group and therefore a true experiment cannot be

Table 1. Evaluation Levels

Level	Measurement Focus	Questions Addressed
1 - Reaction	trainees perceptions	What did trainees think of this training?
2 - Learning	knowledge/skills gained	Was there an increase in knowledge or skill level?
3 - Behavior	Work-site implementation	Is new knowledge/skill being used back on the job?
4 - Results	impact on organization	What effect did the training have on the organization?

conducted. In these cases, measures of pre- and post-training scores should be reported along with anything outside of the training that could have impacted those scores.

Level 3 – Complexity increases for this level because some of the data should be gathered some time after the training has been completed. To assess whether or not what was learned during the training is making any difference in the workplace, trainees must have the opportunity to use their new knowledge and skills. Ideally, activities in the workplace should also be measured before training so change can be assessed. But "...something beats nothing, and I encourage trainers to at least do some evaluation of behavior, even if it isn't elaborate or scientific. Simply ask a few people: 'Are you doing anything different on the job because you attended the training program?' If the answer is yes, ask, 'Can you briefly describe what you are doing and how it is working out? If you are not doing anything different, can you tell me why? Did you learn anything that you can use on the job?'" (Kirkpatrick, 2001. p. 128) If Level 2 data shows that something was learned, but Level 3 data reveals it is not being used in the workplace, then the problem may be related to organizational variables such as authority hierarchies or access to equipment or tools.

Level 4 – To conduct an evaluation at this level a clear link between the training goals and the needs of the organization must exist. This level shows what impact the training program has at an organizational level and is frequently tied to costs/benefits types of analyses. Accident and injury data is often used in computations for safety and health training at this level. Other information such as changes in use of sick leave, absenteeism, costs of personal protective equipment could also provide information about organizational change resulting from training. For this large-scale analysis, variables outside of training may interfere and make measurement of training effects difficult. Because of this proof that training has made an organizational change is not required for findings to be of value. Kirkpatrick says to, "...be satisfied with evidence, because proof is usually impossible to find." (Kirkpatrick, 2001. p. 129) A well-planned evaluation can provide compelling evidence about the organizational impact of a training program.

Scope of the Evaluation

The comprehensiveness of the evaluation should follow its initial goals. An evaluation of an entire training program will be resources intensive. It should be conducted when an assessment of the program is needed for policy decisions about the worth of the program and/or changes needed to improve on ongoing program's effectiveness. Often only one portion of a program is the appropriate target for an evaluation. One course or a set of courses covering related material is assessed at completion to report back to interested people about the course(s). Similarly certain instructors can be assessed by gathering data only about their work. The desire for information should always be balanced with the time, personnel, and funding available for the evaluation tasks. A clearly defined evaluation plan will keep data-gathering focused on what is really needed to

answer the question of importance for the intended audience of this evaluation.

Internal versus External Evaluation

The answer to the question of who should design and conduct an evaluation depends on the purpose of the assessment and the resources available. If a person who is part of the program being evaluated also has a role in the evaluation, he or she can add insight obtained by their other program tasks and involvement. There will be little time needed to learn about the structure of the program and its goals. It is often also cost effective to use someone already being paid by the organization for program-related tasks. On the other hand, it may be difficult for a program staff member to assess it objectively. This is particularly problematic when an evaluation could have a negative impact on this individual's career. Even when an internal evaluator wants to conduct an objective evaluation, participants are sometimes reluctant to give negative feedback to instructors or others with direct relationship to the program.

When an external evaluator is selected to assess some aspect of training, the chance for bias decreases. Participants are more likely to report their opinions to outsiders if they have anything negative to say. Even constructive criticism is provided more openly to a neutral party. But there are some cons to choosing external evaluation. Usually they require more resources than internal assessments. Even if the evaluator is brought in from another part of the organization and therefore is not a contracting cost, the evaluation will take longer than an internal one so it will cost more in salary. This is because the external evaluator will have to "get up to speed" on the structure and purpose of the program as part of assessment activities. An external evaluation may add objectivity, but will also add cost. These two competing factors will have to be weighted when determining evaluation goals.

Methods for Data Collection

Data gathering techniques are the most well known aspect of evaluation. Related tools are used to collect data for assessment and for validation purposes. Assessment is the measurement of the practical results of the training and validation determines if the objectives or goals of the training were met (Clark, 1997). The first column of Table 2 lists techniques that can be used to gather evaluation data. The second column tells when this technique would be used and the third column addresses what findings can be gathered with each method. (Mallett and Reinke, in press) The following text discusses the use of each technique in more detail.

Questionnaires. A relatively quick way to get a limited amount of information from a large number of people is a written questionnaire. A well-designed questionnaire can get valuable data, but a poorly designed questionnaire will simply be a waste of time. Some important considerations when designing or assessing a questionnaire are the ambiguity of the questions, the kinds of answers allowed, the formatting of the questions, and the appropriateness of the questions with relationship to evaluation goals.

Questions must be written clearly so that they will be interpreted in the same way by all respondents (Babbie, 1998). For example a question that could be asked to assess a safety training class is: *"Did you learn something new during this class?"* This question can be answered in terms of what was learned about the instructor, the format of the class, a specific topic covered or not covered, or the trainee's perception of management support for the training. The trainee may also elect to put a simple Yes or No as a response. A more specific way to ask this question would be: *"Please list any new first-aid techniques you learned during this class?"* This more targeted question is more likely to meet the evaluation goals.

Table 2. Data Collection Methods

Method	When Used	What can be Learned
Questionnaire	Before, during, or after training	• Perceptions of trainees or supervisors • Opinions of content or training experts • Knowledge or skills • Transfer of training to job • Organizational impact
Interviews	Before, during, or after training	• Perceptions of trainees or supervisors • Opinions of content or training experts • Knowledge or skills • Transfer of training to job • Organizational impact
Classroom observations	During training	• Perceptions of trainees
Performance tests	Before, during, or after training	• Trainee skills
Written tests	Before, during, or after training	• Trainee knowledge
Workplace observations	Before or after training	• Trainee knowledge or skills • Transfer of training to job
Games	During training	• Trainee knowledge or skills
Group discussion	Before, during, or after training	• Perceptions of trainees or supervisors • Opinions of content or training experts • Knowledge or skills • Transfer or training to job
Analysis of statistics	Before or after training	• Organizational impact

Questions can be designed to be closed-ended or open-ended. Closed-ended questions offer specific answers for the respondent to select. It is important that all possible answers are covered and that each answer is distinct from the others. Close-ended questions result in data that are easy to analyze but limit the amount of depth provided in the responses (Babbie, 1998). An example of a closed-ended question is: *"Would you recommend this class to other employees with your level of experience? (Please circle your answer) Yes No"* An open-ended version of this question could be: *"What about this class would make you recommend or not recommend it to other employees with your level of experience?"* An open-ended question can be used to gain more detailed information, but it is more difficult to

analyze. Sometime open and closed-ended questions are combined. For example you could ask: *"Would you recommend this class to other employees with your level of experience? (Please circle your answer) Yes No, If Yes, why?"* The amount of detail wanted has to be balanced with the effort available to analyze responses.

Even if all the questions are well written, optimal data will not be gathered if they are not formatted appropriately on the page. A questionnaire should not intimidate the respondent with too many words, too small a font, unfamiliar technical terms, or too high a reading level. There should be plenty of space available for answers to be written and directions should be clear. It is better to get fewer well thought-out answers than to get many that are hurried through or are incomplete because of limited space on the page. After a questionnaire is drafted it should be tested with people similar to those who are the targeted respondents.

Interviews. Interviews can also be used to capture trainee impressions of the training session. Many trainers already ask trainees their opinions about training sessions without thinking of the conversations as interviews. Certain techniques can be followed that can make these conversations valuable evaluation tools. Compared to a survey, interviews are more flexible and ongoing, but interview techniques apply many of the skills used to construct effective surveys (Babbie, 1998). Interviews must also be designed with clearly written questions. But when the questions are asked orally, further explanation is possible if the trainee doesn't understand. This of course requires a full understanding of the questions by the interviewer. If multiple people will be gathering the information, they must be trained so that all of them understand the questions and are asking them in the same way. Interviews are best when detailed information is wanted from a limited number of people.

During an interview, open or closed-ended questions can be used. The best feature of the interview is that follow-up questions can be asked to illicit responses with more depth or that more closely target the evaluation needs. An example of a question with targeted follow-ups is: *"Have you ever taught someone to operate this kind of equipment? Yes No;* If they answer yes ask: *What written resources (examples: checklists, manuals, laws, safe operating procedures) were available to you to use during that training? What kind of written materials would help someone who is training another miner to operate this equipment?* The interviewer must know enough about the topic to understand the answers give to open-ended questions and to ask for clarification of answers when they are not easily understood.

Classroom Observations. Trainers observe the activities occurring during their classes. They watch trainee behavior and responses to ideas, activities or questions. Documentation of these observations is another source of data for training evaluation. It is best to write down what the trainer or another observer sees while the session is occurring. Actions (both verbal and non-verbal) should be written down as well as comments that seem to form a pattern of activity, change the course of the session, or standout as noteworthy. If notes cannot be taken during a session, then quick notes using short words and phrases to describe events should be written as soon as possible after session has ended. The trainer or observer should record what they 'know' happened and what they 'think' happened during the session (Babbie, 1998). After completing this quick sketch of the session, they should review the notes and fill in the details as soon as possible. The longer the delay in writing down observations from a session the less likely actions and events will be recalled accurately and completely. It is helpful to have an observation guide such as the on found in Appendix A to help the trainer or observer to remember to take note of important actions.
Written Tests

Trainee knowledge can be assessed with written examinations. Care should be taken when using this method, as many working adults will become anxious when they think they are being tested. The tests must be constructed in a manner that allows trainee knowledge to be written and interpreted by the trainer. A well-designed exam should allow those with more knowledge of a topic to perform better than those less knowledgeable. To determine if trainee knowledge change is a result of training, a pre-test and post-test will have to be administered. Outside influences can impact the results of this kind of study as was discussed earlier. If the purpose of the test is to assess the quality of the training rather than the performance of the individual trainees, they should be aware of that purpose. Their anxiety level may be somewhat lessened in those situations.

Workplace Observations. Like classroom observations, workplace observations are already taking place in many instances. To include them training assessments, they need to be formalized and documented. The trainer, a supervisor, or some other observer can conduct the observations. This method is useful for determining if skills learned during training can be transferred to the work environment. A checklist of what should be observed should be used. This checklist could be created as a job-aid and also used in training.

Games. Trainers often use games during their courses. These break up the day and allow trainee interaction. They can also be effective evaluation tools. Trainers can determine if trainees know select materials by the answers they provide during an adapted version of football, bingo, or a television game show. A crossword puzzle can be used as a review or to test knowledge of terminology. Games are a good way for trainers to informally determine if their course is working for this particular group of trainees. The games should always focus on important information and anytime an answer is incorrect or false, the correct answer must be presented and discussed. Trainees often enjoy classroom games and do not think of them as tests, but they can be used to evaluate training effectiveness.

Group Discussion. Interviews can also be conducted in groups. The questions asked should be defined, but the interaction created by multiple individuals answering will make recording the responses more difficult. There may be more information obtained as people make comments that stimulate thoughts in others in the group. On the other hand, if the group members are not comfortable with each other, they may not express their real opinions. For example, care must be taken when discussing work with a group containing both employees and supervisors. Group composition, finding a comfortable location for the discussion, the questions to be asked, and how the answers will be captured must be considered designing an evaluation with this method included.

Analysis of Statistics. Sometimes analyses of statistics such as accident rates, near misses reported, maintenance costs can be used to evaluate training. When designing a training evaluation, the availability of records should be explored. Whether or not the numbers can be tied directly to the training activity is an important consideration. Outside variables that could impact the statistics must be considered and clearly stated in the final report if this type of data is used.

Analysis and Reporting of Results

If the implementation of the evaluation followed a clear design, then analyses will be straightforward. The data collection methods that were used are tied to given analysis procedures. The most important thing to remember is to target the analysis to questions asked when the evaluation goals were defined. While this may seem obvious, it can be tempting to explore other things that can be found in the data. While it may be appropriate to scan the data for unplanned outcomes, this will take resources away from the initial goal and

should be done only after the primary evaluation goals are met.

Reporting of evaluation results can take many forms. Written reports, oral briefings, or multi-media presentations can be used to convey findings. Often results should be reported in more than one way to meet the needs of different interested parties. More or less detail can be provided and the level of sophistication of the results can be varied. In all cases it is important to limit any public availability of information that can harm or embarrass any individuals. When assessing trainers, it may be necessary to provide negative feedback to that person and/or related managers. In those cases, care should be taken to offer the data in as positive or constructive manner as possible. Any time public harm or embarrassment results from an evaluation report, everyone involved and people who simply hear of what has occurred will be less likely to participate openly in future evaluations. A determination of who will have access to what kinds of results should be determined during evaluation planning and reporting should follow those guidelines.

In Summary

Developing and implementing a training evaluation is sometimes thought of as an abstract and unordered process. In fact a well designed evaluation is a structured process that produces results useful to an organization.

When designing a training evaluation it is critical to address specific issues. These evaluation characteristics include determining the purpose of the evaluation, what aspects of a training program need to be evaluated and the individuals who want to review or need access to the evaluation results. After those items are defined, choosing who will create and execute the evaluation, the resources available for implementing the evaluation, and the collection methods used to gather data can be determined. An organization taking the initial steps towards producing a training evaluation needs to integrate their specific organizational qualities and needs into the evaluation design plan. A worksheet is provided in Appendix B to serve as an outline for the development of a training evaluation.

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Appendix A
Guide for Observation of Simulation/ Response of Trainees

Before training starts, observe the trainees and make note of this starting point. The trainees' voices, sitting positions, body language and comments can serve as a control or point of reference to compare those same actions as the class progresses.

Observe Changes/Lack of Changes in the Following:

Body Language

- Facial expressions that signify stress, anxiety, comfort, confidence, etc.
- Changes in posture, position in chair
- Movement of hands
- Movement of feet/legs
- Changes in voice/language/delivery

Social Interaction

- Observe group dynamics – did they work together or separately?
- If they worked in groups, did those groups change over the course?
- Were there particular points when trainees asked each other for help?

Interaction with Training Materials or Multimedia

- Were trainees comfortable with the format of the material?
- Did they have problems using the technology?
- Did they assist each other with the materials?
- Did they seem to understand the content of the materials?

Appendix B
Training Evaluation Worksheet

Use this worksheet as a guide to help organize the development of a training evaluation.

Plan the Evaluation

1. What are the goals of the evaluation?

2. What questions about the training will the evaluation answer?

3. Who will design and conduct the evaluation?

4. What resources are available for evaluating the training program? (Time, Money, Equipment)

Gather the Information

1. What method(s) will be used to gather information?

Data Collection Method	Performed (circle choices)
	Before, During or After Training
	Before, During or After Training
	Before, During or After Training
	Before, During or After Training

2. How should the gathered data be presented?