THE UNITED STATES DEPARTMENT OF HEALTH AND HUMAN SERVICES

CENTERS FOR DISEASE CONTROL AND PREVENTION

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH)

MINE SAFETY AND HEALTH RESEARCH ADVISORY COMMITTEE (MSHRAC)

SPRING MEETING

NIOSH PITTSBURGH MINING RESEARCH DIVISION

BRUCETON, PA

VIRTUAL ON ZOOM, OPEN TO THE PUBLIC

TUESDAY, MAY 17, 2022

WEDNESDAY, May 18, 2022

Contents

Summary Proceedings

The spring 2022 meeting of the National Institute for Occupational Safety and Health (NIOSH) Mine Safety and Health Research Advisory Committee (MSHRAC) was convened at the NIOSH Pittsburgh Campus, Building 140, Room 140MP, 626 Cochran Mill Road, Pittsburgh, Pennsylvania, on Tuesday, May 17th at 10:00 a.m., Kyle Zimmer, Jr., Chair, presiding. The meeting was also open to the public both in person and by video teleconference.

The meeting was then reconvened on Wednesday, May 18th, again via video teleconference, at 10:30 a.m. EST with Kyle Zimmer, Chair, presiding.

Attendees

Members Present in Person

Kyle Zimmer, Jr., International Union of Operating Engineers; Chair

Ronald Bowersox, United Mine Workers of America

Andrea Brickey, South Dakota School of Mines and Technology

Tom Duffy, United Steelworkers of America

Todd Moore, CONSOL Energy (*Membership Nomination Pending*)

Elizabeth Pritchard, National Stone, Sand & Gravel Association

Steven Schafrik, University of Kentucky

Matt Stewart, R. T. Vanderbilt Holding Company, Inc.

Giovanna Biscontin, National Science Foundation, Ex Officio

Melanie Calhoun, Mine Safety and Health Administration, Ex Officio

Members Present via Video Teleconference

Kristina Behringer, M.D.

Marifran Mattson, Purdue University

Non-Members

George Luxbacher, Designated Federal Official, NIOSH Deputy Associate Director for Mining

John Howard, NIOSH Director

Doug Johns, NIOSH Spokane Mining Research Division Director

Cara Halldin, NIOSH Spokane Mining Research Division Deputy Director

Jessica Kogel, NIOSH Associate Director for Mining

Pauline Benjamin, NIOSH OD

Bob Randolph, NIOSH Pittsburgh Mining Research Division

Stephen Sawyer, NIOSH Pittsburgh Mining Research Division Director

Members Unable to Attend

Aubrey Miller, National Institutes of Health

Welcome and Meeting Logistics

Dr. George Luxbacher

Deputy Associate Director for Mining

National Institute for Occupational Safety and Health

Centers for Disease Control and Prevention

Dr. Luxbacher, as the Designated Federal Official for the Committee, called to order the open session of the spring 2022 meeting of the NIOSH MSHRAC at 10:00 am Eastern Daylight Savings Time (EDST) on Tuesday, May 17, 2022, in the Building 140 multipurpose room at the Pittsburgh Mining Research Division in Bruceton, PA; the meeting was also available via Zoom. A roll call of all MSHRAC members confirmed that a quorum was present. The roll was also called following each break and lunch to ensure that a quorum was maintained. A quorum was maintained throughout the day.

No conflicts of interest (COIs) were declared. Committee members were instructed that, if a conflict of interest comes up at any time during the meeting, they were to declare that conflict and recuse themselves from any discussion or voting on that matter.

Members of the public in person in the meeting room and on Zoom were notified that they would only be able to listen to the meeting, not comment or ask questions, until the Public Comment period, scheduled at the end of the presentations on Wednesday, May 18, 2022, although those attending remotely could submit questions online via the Zoom chat feature to be addressed in the Public Comment period.

Announcements and Introductions

Dr. Luxbacher welcomed everyone and reviewed the two-day agenda for this meeting. He then reviewed the structure and history of MSHRAC, initially established in 1969.

Agenda

Mr. Zimmer, MSHRAC Chair, welcomed the Committee members. Mr. Zimmer then asked for an approval of the minutes from the prior meeting. Mr. Bowersox made the motion, seconded by Dr. Brickey. The floor was opened for discussion and the motion was then approved.

Report from the Associate Director for Mining

Dr. Jessica Kogel

Associate Director for Mining

Director, Office of Mine Safety and Health Research (OMSHR)

National Institute for Occupational Safety and Health

Centers for Disease Control and Prevention

Dr. Kogel welcomed everyone to the meeting. She then began her presentation, with brief updates on the Mining Program FY2022 budget, Lake Lynn Experimental Mine (LLEM) replacement, implementation of a Laboratory Quality Management System (LQMS) across CDC, progress toward bringing employees back to work, Mining Program Strategic Plan update and highlights for each Division. Much of the discussion around these topics was given in the context of the program's mission: eliminate mining fatalities, injuries, and illnesses through relevant research and impactful solutions. All Mining Program activities are guided by core values of relevance, impact, innovation, integrity, collaboration, and excellence.

On 3/10/22 Congress passed legislation to fund the federal government through September 2022 for $1.5 trillion. The bill provided $351,800,000 for NIOSH in discretionary appropriations, an increase of $6.5M over the FY 2021 enacted level. The agreement included a $1,000,000 increase for grant activities for Underground Mine Evacuation Technologies and Human Factors Research. The agreement provided funding to support the replacement of the LLEM and requested continuation of quarterly updates on progress in the construction of the facility, costs incurred, and unanticipated challenges which may affect timeline or total costs until completion. Funding for the Mining Program was flat compared to previous years and did not cover increased costs in salaries (for FY22, 2.7% broken out as a 2.2% increase in base pay and a 0.5% increase in locality pay) and benefits, for example.

Since the last MSHRAC meeting, the following progress towards the Mace property acquisition to replace the LLEM has been made. An inspection of the Mace property for the Department of Justice was completed by CDC and GSA. GSA & NIOSH met with the Pocahontas County Public Service group to begin discussions about the project and to set timelines. The title search is still underway and involves verifying that there are no issues related to the original property owners, most of whom are no longer living.

CDC has been working on implementing an agency wide LQMS system for the last several years. Much of the focus is on QM for surveillance and other public health data generated by CDC and

shared with the public typically though state public health departments. Because CDC and NIOSH data are used globally for policy, regulatory and other far-reaching decisions, they must meet the highest quality standards as captured by the vision for this program. There have been many internal discussions about the system and its function. Because there are a wide variety of different types of laboratories across CDC (chemistry, biology, analytical, industrial hygiene, engineering, etc.) ranging from those that provide routine analysis to one-of-a-kind research laboratories that provide specialized data, the plan will be highly flexible and will focus on compliance vs accreditation depending on the type of laboratory or activity under consideration. NIOSH will have its own plan and will write and implement it.

Many CDC employees are back onsite, and this was accomplished through a phased approach that has now been completed. The approach followed a flexible workplace policy that prioritizes health & safety and is based on a hybrid work environment that includes onsite work, telework and remote work options. Eligibility for each of these 3 options depends on the type of work performed for a particular position. Masking is optional depending on COVID levels in the local community. Everyone, regardless of vaccination status, must wear a well-fitted mask while in CDC-owned and -leased facilities when the COVID-19 community level in the county where the facility is located is high. When the COVID-19 community level is low or medium, masks are optional for everyone.

Since the fall meeting the Mining Program has completed the annual update to its strategic plan. Updates include those that are considered routine maintenance and occur annually. Examples of updates that fit into this category include adding hyperlinks for new projects and removing old projects, updating activity goals, and verifying existing activity goals, updating statistics and other data with MSHA Injury and Illness data so that is current, updating Partnership information and adding links to new partnership pages, updating future research directions and emerging issues as needed. In addition to making routine annual updates, changes are made to enhance the value and functionality of the plan, such as increased emphasis on impact and evaluation planning, enhanced project pages with keyword search capabilities, and clear alignment to the research domains and subdomains presented at the previous meeting. There will also be alignment with the NIOSH Strategic plan to include diversity, inclusion, vulnerable populations, and health equity.

Division highlights from SMRD are the following. Over the last 24 months 3 new projects have started. One project evaluates open pit bench catchment design guidelines and refines alarm trigger thresholds for slope monitoring. Another develops a framework to minimize the risk of working with autonomous mining equipment. The third project identifies and characterizes health hazards at mine sites. Partnerships and collaboration continue to be a priority for the division and both the Miner Health and Mine Automation and Emerging Technologies Health & Safety Partnerships continue to grow with productive meetings held semi-annually. Other collaborations include engaging with partners to reduce OSH risk related to the domestic supply of critical minerals (e.g., Co, Li etc. for electronics, advanced batteries, etc.) and resuming field work with industry partnership.

PMRD has also had significant collaborations since the most recent MSHRC meeting. These include two significant efforts with teams led by New Mexico Tech (NMT) and Missouri

University of Science and Technology (MUS&T) with the goal of enhancing extramural research through active participation of NIOSH Researchers. Accomplishments include designation of NIOSH Project Scientists, identification of Subject Matter Experts (SMEs), numerous formal/informal interactions with MUS&T, kickoff meetings and several consultations with NMT, planned efforts to follow a Battery Electric Vehicle Safety Workshop hosted by MUS&T, and other collaborative meetings.

At the conclusion of her presentation, Dr. Kogel asked if there were any questions. Matt Stewart asked about the resource impact of the laboratory quality audits. Dr. Kogel responded that NIOSH has provided administrative and managerial support and a number of our staff have also gotten involved; while this definitely requires a resource commitment, the longer-term benefits well outweigh the short-term burden. Chair Zimmer, as a point of clarification, asked if the Strategic Plan was online and Dr. Kogel noted it was. Dr. Luxbacher then clarified that the additional $1 million included in the FY21 budget was earmarked for the Underground Mine Evacuation Technologies and Human Factors Research U-60 grants, not the Mining Program intramural use, and that this continued our flat funding.

PMRD Overview

Dr. Stephen G. Sawyer, Jr.

Director for Pittsburgh Mining Research Division

National Institute for Occupational Safety and Health

Centers for Disease Control and Prevention

Dr. Sawyer gave an update from an organization standpoint of the Pittsburgh Mining Research Division (PMRD).

In April, the Pittsburgh Mining Research Division Bruceton Campus went from a voluntary on-site status to an "open" status for all employees. Under that open status, PMRD implemented a situational telework arrangement for all employees. That model is based on professional expectations and effective communication where the need of the work or the team dictates the working location for the employee. This model also places an emphasis on the development of a healthy balance between work and home life for the employee.

From a budgetary standpoint, as has been mentioned previously, the Mining Program is flat funded. Being flat funded means the ceiling of available money does not increase, however, as the costs associated with operation increase, the discretionary funds needed to perform the critical tasks of research projects shrink. To help combat these shrinking discretionary funds, PMRD is employing attrition along with strategically moving personnel within the Division to gain the fullest potential out of those individuals.

PMRD is also working to leverage external collaborations to increase its portfolio. PMRD is actively participating in U60 Grants and Broad Agency Announcements (BAAs) and always looking for external opportunities to advance its work.

Even with the increasing constraints, PMRD personnel were able to participate in almost 30 field visits and produced 75 outputs in varying forms such as presentations, articles, infographics, etc. PMRD will continue to strive to improve our effectiveness and deliver excellent research that can be used by its stakeholders and interested parties in satisfying our mission of protecting the health and safety of the miners.

Health Hazards Prevention Branch

Increasing the Effectiveness of Targeted Mining Hearing Conservation Program Elements at Surface SSG Mining Operations (93909Q0)

J. Shawn Peterson

MSHA requirements for hearing conservation programs have been in place for over 20 years, yet miners still suffer from occupational hearing loss and noise exposure levels remain high. This raises the question, why aren't HCPs more effective? Mining companies have implemented these programs per MSHA requirements but reductions in incidences of hearing loss and exposure levels remain high.

Sound contour mapping can be used to illustrate high noise areas, and it is content that can be easily understood. From the contour maps, recommendations can be made for site or personnel modifications, such as signage, blinking lights, or restricted access. In the past, NIOSH has accomplished this using various software packages that may not be available to health and safety professionals. Current methods required post processing of data, but NIOSH is developing an application that's easy to use and produces results quickly.

Practical guidance based on noise surveys and dosimetry can reduce noise exposure. Noise surveys can be as simple of collecting sound levels with a sound level meter (SLM). A more time intensive method includes using coupling dosimetry with time-motion studies to determine what a worker is doing when exposed to the highest noise levels and/or accumulated the most noise dose. An even better method is including Point-of-View (POV) video as a tool to link activity to noise levels and dose accumulation.

A significant application of the contour mapping, and a milestone for the project, is the alerting of workers to high noise areas at a surface quarry. The surface quarry used sound contour mapping to help reduce worker noise exposures. Workers exiting the processing building and walking near the rotary dryer to the storage building walk in a common pathway. The flame and propane hiss of the dryer create high noise levels in that area, but, if they keep to the right of the stairs, and walk directly to the storage building, they are exposed to less noise. It was found that workers also tended to congregate in the high noise area. These pathways are effectively communicated to the workers and the quarry placed contour maps and yellow markers delineating quieter traveling paths

Another application and milestone for the project was an open pit mine and processing plant using POV video and SLM data to reduce worker noise exposure. At the open pit mine, POV video, SLM data, and the NIOSH-developed application, EVADE, were used to evaluate two workers and their job tasks. Worker 1, the manual bagger, loaded bags of ore into bags and then onto pallets and encountered peak sound levels around 102 dBA. A second worker drove a forklift, transporting bagged ore from inside the processing plant to an outside area prior to transport. Based on the POV video and SLM data, the mine utilized administrative noise controls for workers 1 and 2, alternating them between the manual bagging and the forklift driving. This case study and similar results have been published, with the objective of informing the industry how this was accomplished.

At the conclusion of Mr. Peterson's presentation, there was considerable discussion with the Committee. Chair Zimmer asked when contour mapping would be available; the program is near completion and will be sent for Beta testing within a few months, despite COVID-related delays. The intent of the application is to be user-friendly, providing results with minimal technical background on the part of the user and with simplicity in operation. Mr. Duffy asked about the accuracy of the microphones on the various smart phones; a calibrated source can be used for accuracy or, if one is not available, a calibration procedure is built into the application to minimize that impact. Tests are also being run on earlier and current versions of smart phones to confirm results will not change. Ms. Pritchard asked about the impact of constantly changing noise levels, either due to machines switching on and off or operation status (cutting, idle); the app is designed for a stationary noise source operating at constant conditions. Ms. Biscontin asked about the availability of a wearable monitor that tracks noise levels; a monitor was available that clipped on to a hard hat and gave an indication through lights as to the worker exposure, but it never took off commercially. Ms. Calhoun asked if the NIOSH Mining Program had been in contact with OSHA regarding the app; the NIOSH Mining Program has been focusing on how this app could be used to improve the use and acceptance of hearing conservation programs in mining and had not reached out yet to OSHA. Mr. Schafrik suggested that the app data include maximum values and the time period for averages to correspond with worker exposure limits; the sampling period is user selectable, from 5 to 60 seconds. Mr. Peterson highlighted the use of the app in evaluating engineering controls to reduce noise levels by developing contour maps before and after the controls are in place; the app includes a function to compare the two contour maps and look at the control impact. Mr. Bowersox asked about the applicability of the app underground for equipment such as a roof bolter or longwall; provided the equipment was outby where a non-permissible smart phone or tablet could be used, the app would be useful. Ms. Pritchard asked if contour maps could be switched together; while that has been discussed, the current version doesn't include that capability. She then asked if there were any plans to integrate the NIOSH Sound Level Meter app into this app; while the NIOSH Mining Program has been talking to the developers of the Sound Level Meter app, it includes enhancements that are not required for the contour mapping, although both apps use the same smart phone capabilities. Mr. Steward commented that sound level control is not a glamorous research topic, given the prevalence of hearing loss in the mining industry, this type of research is critical.

Prevention of Manual Materials Handling Injuries in Mining (9390BMP)

Dr. Mahiyar Nasarwanji

Material handing is the leading accident and injury classification accounting for 36% of all non-fatal incidents. When talking about manual material handling the back is often the area of focus. However, there are two other areas that warrant attention that we are focusing on; 1) shoulders, as they have four times the days lost due to long recovery times, and 2) hand and fingers, as they are the most injured body part but neglected due to short recovery times.

This project has three specific goals:

1. Evaluate the efficacy of using shoulder support exoskeleton to reduce the physical demands associated with manual material handling tasks through empirical testing

2. Develop workplace guidance to prevent hand and finger injuries through an analysis of MSHA data, interviews, and a systematic literature review

3. Provide mining specific guidance to reduce manual material handling injuries on the NIOSH mining website

To identify key areas of interest for the shoulder we looked at 5 years of MSHA data related to shoulder strains and sprains. We identified underground coal mines and stone mill and preparation plants as key areas to focus on. When looking at activities, maintenance and material handling were the two major contributors. For maintenance, it was related to vehicle maintenance and belt maintenance. For material handling it was moving objects and loading and unloading items.

Emerging technologies such as exoskeletons have been successfully used in other industries to reduce physical load on the shoulder. We have already identified some tasks of interest where shoulder support exoskeletons can help, such as building stoppings and handing cable. We are currently setting up the lab to conduct empirical testing on exoskeletons that includes building a test wall based on NIST guidelines where we can simulate tasks like cable handing, lifting boxes, and drilling. The next steps are to get IRB approval to start the empirical testing. Other industries have successfully used exoskeletons to reduce shoulder injuries, based on this work stakeholders could use exoskeletons to reduce physical demands for some manual material handing tasks thereby reducing shoulder injuries in the mining industry.

An evaluation of 7 years of MSHA non-fatal injury data reinforced that hands and fingers are a major concern; with incidence rates for hands and fingers injuries nearly double of that of the back, the next most affected areas. Five activities accounted for over 75% of all injures, with material handling and maintenance and repair being the top two. When looking at materials handled, miscellaneous metals (pipe, wire) and metal guards were the top two and common across material handling and maintenance and repair activities. This information is useful in developing guidelines to prevent hand and finger injuries as it highlights that we need to use a hierarchy of controls to help reduce injuries and not only focus on PPE.

Although MSHA injury data is not designed to capture PPE-related information, looking at gloves provided some valuable insights. Gloves were explicitly mentioned in about 7.5% of all injury cases evaluated, but gloves contributed to the injury in about 20% of those cases, specifically due to the hand getting caught in, under, or between an object. This is obviously a small sample but there is a need for more research in this area. When looking at gloves further, there's a disconnect between the types of injuries and the types of gloves used. Leather gloves were most commonly cited, and cuts and lacerations were the most common type of injury. However, leather gloves do not provide cut protection unless specified or specially coated. Also fractures and chips were seen when wearing metacarpal gloves, and cuts and lacerations seen when wearing cut resistant gloves; indicating the gloves might not provide the adequate level of protection for hazards in the mining industry.

To develop guidance and performance specifications for hand and finger protection we are currently conducting stakeholder interviews with mine workers, mine management, and glove manufacturers related to hand and finger injuries, tasks, glove policies, and performance testing. We are also conducting a systematic literature review to look at glove performance and usability.

Information from this project is already available to stakeholders via the NIOSH manual material handling website which has been updated with new statistics and relevant resources. As we collect more data and publish the findings this website will be updated.

Advance Strategies for Controlling Exposures to Diesel Aerosols (93909Q3)

Dr. Aleksandar Bugarski

Diesel engines that are the primary source of power to mobile equipment in underground mines are a major source of exposures for workers to submicron aerosols and criteria gases (CO, NO, NO_2). However, recently introduced advanced engine and exhaust aftertreatment technologies provide the mining industry with tools to address that issue.

This project supports the underground mining industry's efforts for clean, economical, and dependable power for mobile equipment. The focus is on providing critical information to the mining industry on the benefits of various aspects of integrated approaches toward reducing exposures. The emphasis is on: (a) implementation of advance diesel engines in underground operations, (b) improvement of environmental enclosures and filtration and pressurization systems for heavy-duty and light-duty underground mining vehicles, (c) implementation of diesel canopy air curtains (dCAC) for various utility vehicles in large opening mines, and (d) improvements in an emission-assisted maintenance program for advanced engines.

A series of laboratory and field studies conducted during this effort provided data critical to the selection and optimization of exhaust aftertreatment systems and advanced engines. These data supplement data generated through the EPA certification and MSHA approval processes. For example, the results of tests conducted at the NIOSH PMRD Diesel Laboratory showed that Tier 2 engines retrofitted with diesel particulate filters can provide better reductions in diesel particulate matter (DPM) emissions than a Tier 4 final engine equipped with an SCR system only. This

research confirmed that available control strategies, when properly optimized and deployed, can dramatically reduce exposures of underground miners to diesel aerosols.

The team has also been working on advancing methodologies for monitoring ambient concentrations of diesel aerosols and performance of engine/exhaust aftertreatment systems. The NIOSH PMRD Diesel Team was invited by Freeport McMoRan to assist them in developing methodology for continuous monitoring of DPM concentrations in underground operations. Methodology based on the use of Dekati DePS-Go monitor was developed and evaluated at Freeport McMoRan Henderson Mine. The Diesel Team is currently conducting a series of tests that will help them develop advanced methodologies for periodic monitoring of performance of diesel particulate filters.

The team is also working on the strategies that can be used to reduce exposures to the diesel aerosols that are released in the underground environment. These efforts are focusing on developing a dCAC system and effective filtration and pressurization systems for environmental enclosures. Currently, the team is evaluating a dCAC system for an ANFO loader developed in cooperation with Fletcher Mining Equipment. The preliminary results showed that potential reductions in exposures of the blasters could be up to 78%. The team is also working on developing a laboratory test facility that will allow for evaluation of environmental enclosures and filtration and pressurization systems in a diesel contaminated environment.

Extensive cooperation with various industry partners enhances the impact of our research. This research helps partners select, optimize, and implement viable control strategies and technologies and reduce the DPM burden in underground mines. Our monitoring and emissions strategies and maintenance methodologies allow the industry to gauge their success in implementing technologies. Our research targets improvements in filtration elements and systems optimized for reducing exposures to DPM.

At the conclusion of the presentation, Mr. Bowersox noted that the UMWA greatly appreciates this work, since only a few states focus on diesel enforcement underground. Dr. Schafrik asked about the area of influence of diesel exhaust; Dr. Bugarski responded that, unlike dust, the diesel aerosol plume propagates across the mine, referencing a NIOSH study at the Deserado Mine in Colorado where light-duty vehicles were the primary source of exposure at the face. Because diesel particulate filters and disposable filter limits are implemented on heavy-duty pieces of equipment, they contribute very little to exposure, but light-duty vehicles are not equipped with DPFs. Since a DPF can be 99 percent effective in removing particulates, all these small, light-duty vehicles which are typically not considered as a source of exposure are actually significant. Chair Zimmer asked if NIOSH studies showed that end users are keeping up with the maintenance schedules for the filters or if there is some type of control that shuts down the engine once a filter has reached maximum life; controls are available, and studies show that good filters can last as long as 5 to 10 thousand hours of operation. Dr. Bugarski elaborated that there are two types of aerosols collected in the DPFs; one is carbonaceous aerosols, and these filters are designed to regenerate. Depending on the state of your engine, if it burns a lot of oil, ash is produced that can't be removed through regeneration and the filter life decreases. A clean engine is required for the technology to work as designed; a DPF on an older engine will not be as effective.

Advancing Exposure Monitoring for Airborne Particulates in Mining (93909Q2)

Dr. Emanuele Cauda

The project Advancing Exposure Monitoring for Airborne Particulates in Mining is a five-year project in its last year. The project will be concluded at the end of September 2022. Dr. Chubb is working on the creation of a follow-up project to continue working on important elements of the rapid quartz analysis approach.

The main impact of the project is the creation of the rapid quartz analysis which is a field-based monitoring approach. It is composed of three steps with an optional fourth step. The first step is the collection of a respirable dust sample with traditional equipment, generally referred in the mining industry as the gravimetric dust sampler. The second step is the analysis of the dust sample in the field with a portable infrared FTIR spectrometer. The third step is the processing of the raw data created by the spectrometer into information relative to respirable quartz concentration. This is possible using the NIOSH software FAST. Finally, the user has the possibility to send the same sample for laboratory analysis using standard methods. This is possible because the field analysis is non-destructive.

The development of the components was a multidisciplinary effort. The project started from established practices and equipment used to monitor respirable dust and quartz in mining: the rapid quartz analysis approach is compatible with most of the gravimetric samplers used in the mining industry. We have promoted the development of a new sampling cassette optimized for field analysis. We have tested several commercially available portable FTIR units for this approach and we published a comparative study of their performance. In addition, we have designed and made available in the NIH portal, the drawings for 3D printing of components and holders to be used in combination with the dedicated sampling cassette. To facilitate the adoption of rapid quartz analysis, users now have access to the NIOSH FAST software and a recently published user guide. From an analytical perspective, the rapid quartz analysis approach was developed on existing methods by MSHA, NIOSH, and the Health and Safety Executive agency in UK. Since the development of the rapid quartz method, entities such as ISO and ASTM have expressed interest in creating standard methods. Still, we are mindful of the challenge of the analytical method when dealing with respirable dust samples of complex mineralogy, discussed in detail in a recent paper by Dr. Walker. For this reason, we are interested in testing the rapid quartz analysis with respirable mine dust of different origins and we are currently creating multiple chemometric pipelines to train multivariate models to be soon included in FAST, a development led by Dr. Wolfe

The rapid quartz analysis has received positive feedback from mining and non-mining industries. Several coal mines in the US expressed interest and the National Mining Association ran a workshop to present the novel approach. BHP coal in Australia started adopting the technology. In the metal mining industry, Freeport McMoRan has expressed interest for national and international use. The interest can be expanded for many members of the International Council for Metal and Mining. Barrick in Tanzania started using the technology. Several single operators and NSSGA in general have expressed interest in the monitoring approach through the years. Outside

the mining industry, a facility of the department of energy in Georgia, has used the monitoring approach for a few years. The project team has presented the monitoring approach at several industrial/occupational hygiene association conferences with good feedback. Finally, of note, Perkin Elmer has decided to launch an FTIR silica analyzer adopting all the ideas developed in the project. As a project, we have constantly interacted with mining operators, especially in the aggregates sector. We have conducted a case study on the use in the field of the rapid quartz analysis and the Helmet-CAM together with the company New Enterprise. The results of the case study were presented in an article in the NSSGA Stone and Sand & Gravel Review magazine. In addition, New Enterprise used the material from the reports for internal training and awareness activities.

Dr. Cauda then asked if there were any questions. Mr. Stewart asked if the cost of the FTIR, currently between $10 to 20,000 would come down if the FAST method was commercialized; Dr. Cauda responded that it would be very unlikely since these portable instruments that are used for a variety of applications, beyond field rapid quartz analysis. He also noted that traditional silica analysis costs $100/sample, so that analyzing 100 samples/year would break even after 2 years, not even accounting for the benefit of rapid turnaround time. Ms. Calhoun asked how the methodology compared to the MSHA P7 method; the MSHA P7 is the NIOSH reference in terms of comparison and our method was within 10-15 micrograms for coal. Dr. Luxbacher then mentioned that the cost of the CPDM used for compliance by the coal industry is approximately $15,000 for one unit; Mr. Bowersox noted that most mines have over 20 units.

Improved Float Dust Controls in Underground Coal Mines (9390BMK)

Dr. Hua Jiang

The main objective for this project is to reduce accumulations of combustible material in underground mine entries. With that we can improve the rock dusting practices by reducing the amount of rock dust applied in mine return entries. This should reduce the likelihood of mine dust explosions. To achieve these objectives, we are pursuing three different approaches:

- Evaluating the use of a wetting agent (surfactant) for Float Coal Dust (FCD) from non-cutting process.
- Evaluating and optimizing water curtains to reduce FCD accumulations in longwall returns.
- Developing a water-powered scrubber for longwall shearer.

Both field and laboratory testing have been carried out to accomplish these goals. First, the project conducted a field study to examine the effectiveness of the wetting agent in a spray system on FCD control at four belt transfer stations. The findings demonstrated that the addition of surfactant could lead to a significant reduction in dust emissions compared to plain water.

The water curtain performance was evaluated at the longwall gallery. Three different spray types and different spray quantities on the curtain were evaluated. Based on the lab results, the total knockdown efficiency for float dust can be around 50% with 21 sprays, and it can reach almost

35% with only 6 sprays. These numbers demonstrate good knockdown efficiency, but also suggest room for potential improvement.

Air induction capacity for different sprays was evaluated in laboratory conditions. The maximum air induction by a single spray at normal operation pressure can be around 400 cfm. Based on the analysis, a single confined spray is found to be most effective for water-powered dust scrubber application. Our next task is to evaluate the dust knockdown efficiency and air cleaning performance for a venturi spray, which is a unique single confined spray.

This project continues to be engaged with interested parties. Results from each research aim have been disseminated and presented at mining conferences. Coal mine operators are reaching out for guidance of water curtain application and solutions to deal with limited water supply, and there are more water curtain applications being reported in MSHA ventilation plans.

Developing and Improving Respirable Crystalline Silica Dust Controls in Coal Mines (9390DTH)

Lieutenant Tim Beck

NIOSH respirable coal dust control research is being conducted in two projects. These projects are in response to the continuing incidence of Coal Workers' Pneumoconiosis in the mining workforce. The first project discussed is NIOSH's coal dust intervention project, which seeks to promote the adoption of dust controls through development and testing. This project uses a combination of laboratory and field evaluations to test controls and apply them to respirable dust hazards.

This intervention research targets those coal mining occupations that have the highest documented dust exposures, especially roof bolters, continuous miner operators, longwall shearer operators, and jacksetters. The project also targets existing and widely adopted dust controls, seeking to improve their performance. These controls include face ventilation, scrubbers, water sprays, and dust collection systems. During this project, researchers have evaluated roof bolter dust collectors and canopy air curtains for roof bolters and coal hauling equipment, studied interactions between longwall shield sprays and other face sprays, and evaluated airborne dust knockdown of various mining sprays. Additionally, in 2021, NIOSH published a second edition of Best Practices for Dust Control in Coal Mining.

Wet dust collection systems that wet the drill cuttings with a spray have been installed on some roof bolters and subsequently evaluated by NIOSH. The on-board dust collector is modified to create a slurry of drill cuttings, which are discharged as a paste on the mine floor. This change eliminates the typical dry dust accumulation that can create a hazard during clean-out. Cleaning out the wet box simply involves hosing out any sludge that accumulates in the chamber. An underground study at Blue Mountain Energy's Deserado Mine found a 60% reduction in respirable dust exposures when emptying wet dust collectors versus dry. A follow-up study at Arch Coal's West Elk Mine observed similar reductions of up to 88%. Notably, the airborne samples collected during clean-out of the wet collector were found to contain no detectable quartz, compared to between 5 and 10% for dry cleaning. One issue that was identified is that the final paper filter can

get saturated and eventually fail. NIOSH is currently working with J.H. Fletcher & Co. to develop guidance regarding the longevity of disposable filter elements.

Canopy air curtains have been fitted to both roof bolting and coal hauling equipment during the project. These systems blow filtered air over operators and displace air contaminated by dust. A benefit of this approach is that it works effectively for all dusts, whether it's rock dust, coal dust, or silica dust. A field study of roof bolters at Prairie State Generating Company's Lively Grove Mine observed reductions of up to 40% when working downwind of the CM. A study of coal haulers at Peabody's Francisco Mine found reductions of up to 34% overall, with about 60% lower exposures during loading in blowing faces. The potential for preventing respirable dust exposures is compelling. Roof bolting equipment with canopy air curtains are now operating in about 50 U.S. coal mines.

When visiting several high-productivity longwall mines, NIOSH researchers observed that coal would slough off ahead of the headgate shearer drum during tail to head passes. As this coal lands on the face conveyor, a cloud of dust was released and drifted over the walkway. This occurs beyond the reach of typical splitter arm sprays. Some mines have suggested the use of shield mounted sprays to confine this dust to the face. A study in NIOSH's full-scale longwall gallery optimized these underside shield sprays to determine the best configuration. These laboratory tests evaluated the angle of the spray, water pressure, and distance from the face. Steeper downward angles were more effective than shallow sprays oriented toward the face. Higher spray pressures also resulted in significantly lower walkway dust concentrations. Additional tests were recently completed to show compatibility with a typical splitter arm and "shearer-clearer" directional water spray system.

In addition to the previously mentioned field study partnerships, NIOSH has worked with Komatsu Mining to build a full-scale mockup of a continuous miner flooded bed scrubber for evaluating performance when exposed to various dust loading conditions. This allows research to consider filter clogging mechanisms and identify ways to restore scrubber performance. Using this same test fixture, NIOSH is working with University of Kentucky and Virginia Tech to test prototype scrubber screen designs. These screens are designed to reduce clogging, sustaining scrubber performance for longer periods of time. Finally, as a part of an ongoing NIOSH Mining broad agency announcement, evaluations are planned with University of Illinois-Chicago to test miniaturized dust monitoring devices in both a uniform dust chamber and in a simulated mine environment.

Investigating Mining Practices and Respirable Crystalline Silica Exposures in Underground Coal Mines (9390G0R)

Lieutenant Tim Beck

The second coal dust control project looks back at historical mining practices and exposures. This research is a result of the 2018 National Academy of Sciences recommendations to improve the understanding of past coal mine dust exposures. This project seeks to understand any possible changes in coal mining practices and the impact they may have had on dust exposures and

associated lung disease. One of the key practices that is being focused on is rock extraction. To accomplish the project goals, researchers are reviewing official records and conducting field measurements. Successful collaborations are essential to access various historical data sources. The Pittsburgh Mining Research Division of NIOSH is playing a central role in systematically bringing together information from MSHA, Department of Energy's Energy Information Administration, and NIOSH's Coal Workers' Health Surveillance Program.

The first task was to review public records to determine if there have been any temporal changes in reported mining heights. Since 1993, an increasing proportion of underground coal has been produced from seams thicker than 48 inches. This may run counter to conventional thinking that coal seams are getting thinner and thinner as the thicker coal seams are depleted. This may be due to external economic factors, with mines of thinner and less economic seams idling or closing during past industry contraction.

A data use agreement between NIOSH and EIA is currently being established to share non-public information related to coal mine practices, such as coal seam and rock thicknesses for individual mines. This will also provide historical preparation plant performance metrics related to inputs, outputs, and reject rates. Once access to these data is established, researchers plan to analyze them in conjunction with other mining demographic information, such as mine employment and compliance history.

An overall downward trend in MSHA-inspector dust concentrations has continued since 2010, especially since the full implementation of MSHA's New Dust Rule in 2016. During this same period, over 95% of inspector dust samples were at or below the permissible exposure level. Since 2016, over 98% of continuous miner samples were below the current PEL for quartz dust. These observations illustrate an existing range of potential exposures based on occupation, but also how they have changed substantially in just the last 10+ years.

In this project, NIOSH researchers have also reviewed current MSHA-approved ventilation and dust control plans from 110 underground coal mines. The minimum dust control parameters exhibit a range of current operating practices. This effort found that while mines operate within a defined range for most dust control and ventilation parameters, there may be quite a bit of variability within this range. These values have informed ongoing and future NIOSH work. For example, CM scrubber research will use typical airflow quantities to design upcoming laboratory tests. Additional field studies are planned to benchmark current practices and exposures. Work continues with MSHA and NIOSH's Respiratory Health Division and Health Effects Laboratory Division to identify target mines and determine what attributes are most relevant.

In summary, these respirable coal mine dust projects seek to advance existing coal dust controls, provide insight into new technologies, and improve the understanding of past and current exposures. The efforts make use of laboratory and field evaluations to test these interventions under both simulated and actual conditions to improve adoption by industry partners. Ultimately, NIOSH is striving to provide clear and appropriate guidance so that mine operators can mitigate hazardous dust conditions and reduce exposures that may result in CWP and silicosis.

At the conclusion of Lieutenant Beck's two presentations, Chair Zimmer commented that, from his observations during the time he has been on the Committee, this research is starting to pay off; Lieutenant Beck responded that access to the mines has been most important aspect of this, where field evaluations can take place. Only so much can be done in the lab to set the tone, but taking solutions to the mine can really demonstrate their effectiveness.

Smart Respirable Crystalline Silica Dust Systems for Metal/Nonmetal Mines (9390DTJ)

Justin Patts

The "Emerging Respirable Dust Sensing and Control for M/NM Mining" project seeks to test the effectiveness of emerging technologies relevant to lowering M/NM respirable dust exposures. The work is an applied research effort in which the researchers develop and test technologies for both measuring and controlling respirable hazards. By conducting this research and disseminating it, industry will have at its disposal evidence on the effectiveness of these solutions. Such evidence can then be used by industry to justify the installation of controls similar to those tested under the project.

In the first research task, the investigators designed and executed a test of low-cost dust monitors (LCDM) vs reference aerosol instruments, finding that the LCDM performance exceeded that of medium cost units that are widely used in industry. On average, the improvement in correlation between the reference instruments and the LCDM was 15%. The mining industry cannot accept new dust monitoring technologies that have not been rigorously tested and thus this laboratory test is the first step in proving that LCDM have adequate performance on mining dusts.

The second research task seeks to develop an advanced cab filtration system to lower mobile workers' exposure to respirable dusts and fumes. The researchers used a contract vehicle (which is in its later stages) to develop an intelligent cab system which will monitor dust levels and carbon dioxide (CO_2) in real-time and change the operating conditions to offer the mobile worker the best possible air quality. In a collaborative process between NIOSH and SyKlone International, the requirements of the system have been conceptualized and specified and SyKlone has proven the equipment in a shop type setting. A field test is tentatively scheduled for November 2022, where the level of protection offered will be quantified in a field environment at an aggregate operation in South Carolina. Never before has such integrated measurement and control technology been implemented into a cab filtration system for the express purpose of lowering workers' exposure to both dust and CO_2.

The project seeks to both target solutions to stakeholders and build confidence in those controls by proving them in actual mining environments. The performance of the low-cost dust monitors to function as area monitors will be demonstrated in working mines – in screenhouses, loading points, along conveyors and other high exposure areas where respirator use is commonly required full-time. The SmartCab filtration system will be tested at an operating mine and the research staff will learn exactly what kind of protection can be afforded under realistic usage conditions (as miners ingress and egress, with dusty work clothing, as the machine vibrates and is operating over dusty haul roads, dumping and loading material, etc.). The third aim of the project is about testing

controls which are available but for which NIOSH has limited experience with their in-field effectiveness. Investigators will test portable welding fume capture units at their capture efficiency under various conditions as well as treated sands which, while designed to lower RCS exposure at fracking sites, could suggest technologies to lower RCS exposures at mining sites as well.

In summary the project is attempting to combine dust measurement and control technologies in new ways to lower workers' exposure to respirable dusts and fumes. The first half of the project focused on lab developments and the 2nd half will mark a shift towards field evaluations.

At the conclusion of the presentation. Ms. Pritchard asked for more detail on the SmartCab prototype. Mr. Patts noted that the original intent was to integrate it through the original equipment manufacturers (OEMs), but we found that they outsource their filtration needs to third party suppliers. The NIOSH work is consequently focused on developing a system that can be retrofitted to an existing system or used as an alternative to a non-intelligent cap filtration system; research that a non-OEM may not be able to fund. Mr. Stewart asked about the ability of low-cost dust monitors to quantify lower dust and silica exposure limits; Mr. Patts responded that these monitors rely on light-scattering principles, such that anything that changes the optical properties of the dust, size, mineral content, encapsulation by water, etc., will all impact performance. Field research, with varied dusts that aren't homogeneous, will answer this question as the project continues.

Mining Systems Safety Branch

Validating Collision Warning and Avoidance System Detection Performance for Surface Mining Haul Trucks (9390G0S)

John Homer

The purpose of this project is to evaluate parameters and establish methods for the assessment of collision warning/avoidance systems (CXS) detection performance. To accomplish this task, the team's approach is to analyze U.S. surface mining haul truck fatalities by identifying prevalent scenarios and factors relevant to collision warning /avoidance systems and also by setting the scope for scenario-based evaluations. Part of this evaluation involves reviewing methods and parameters to evaluate system detection performance. With this, the team will be able to address gaps in determining real-world detection performance for mining and identify considerations for future research.

The research will consist of simulation, laboratory, and field studies. Simulation studies will involve software tools and algorithms designed for testing driver-assistance systems using time-based inputs and sensor data to investigate and illustrate scenarios that are impractical or unsafe for real-life testing. Simulations will be used to determine parameters that are potentially critical to evaluating CXS detection performance and to set the scope for field testing. Laboratory studies will be used to establish the accuracy of positional data and acquisition equipment. Laboratory efforts will also establish methods for CXS validation and determining system capabilities and limitations. Field studies will be conducted to gather real-world performance data to use as inputs

for the simulations and to evaluate validation methods and testing resources in the real-world at surface mines.

The impact of this project will come through 1) the development of recommendations and guidance for CXS implementation and validation to be used by mine operators, integrators, and manufacturers for improving real-world efficacy, and 2) the promotion of industry adoption, improved operator acceptance, and a reduction in haul truck accidents and fatalities. The success of these outcomes will be measured through:

- Dissemination, via the NIOSH Automation and Emerging Technologies Partnership, research citations, and requests for information
- Implementation, via direct follow-ups and stakeholder interactions
- Standards and Frameworks, via the Association of Equipment Manufacturers (AEM), International Organization for Standardization (ISO), and Earth Moving Equipment Safety Round Table (EMESRT)

Ultimately, this project will benefit haul truck operators and other surface mine workers who could be injured by haul trucks, mine operators seeking to safeguard assets such as equipment and infrastructure, CXS manufacturers seeking to standardize methods to validate their products, and government agencies seeking to write and enforce science-based regulations.

At the conclusion of Mr. Homer's presentation, Chair Zimmer noted that he recently had an opportunity to drive a haul truck in a quarry during Safety Week and was surprised at the lack of visibility around the truck; he commended NIOSH for this research. Mr. Moore asked if the systems being reviewed were passive (giving warning) or active (applying braking); Mr. Homer replied that the systems are passive - informative, providing the operator an indication or information that they would not otherwise have. Mr. Homer also clarified that the systems under review included standalone technologies, such as LiDAR or radar type of technology mounted on the haul truck, as well as tag-based systems, where someone on foot could wear a tag or it could be installed on a light duty vehicle, such as a pickup truck or service vehicle.

Electromagnetic Interference and Electromagnetic Compatibility Considerations in Underground Mines (9390BMM)

Dr. Chenming (Jim) Zhou

The purpose of the EMI and EMC Considerations in Underground Mines project is twofold. First, it must be determined if electromagnetic interference/compatibility (EMI/EMC) challenges within the mining industry can be effectively resolved using existing standards and mitigation strategies applied in other industries. Second, mining-specific recommendations must be developed to overcome EMI/EMC challenges critical to mine worker safety if it is determined that existing standards applied in other industries are not applicable to the mining industry.

Several approaches are being pursued to solve this research problem. The first is characterization of EM emissions, which involves field tests to characterize EM emissions in underground mines using a NIOSH-developed battery-powered portable measurement system and laboratory tests to

quantify emissions from particular electrical and electronic devices. The next is characterization of radio susceptibility of electronic safety systems. This is carried out using a LaplaCell, a shielded test cell used for characterizing radio susceptibility of equipment including gas meters, proximity detection systems, and personal dust monitors. The last approach is the development of mitigation strategies to prevent EMI. Strategies such as shielding, filtering, separation distance, and field cancellation have been developed to reduce EM emissions from devices such as personal dust monitors. The project team is working with equipment manufacturers and other parties to implement mitigation strategies.

This research will result in the development of guidance for methods to quantify EM emissions and EMI susceptibility for devices used in mining, and also mitigation strategies for preventing EMI. This research will be disseminated through various NIOSH partnerships and requests for information, and will be implemented through direct follow-ups with partners, collaborations, and interactions with interested parties. Ultimately the goal is to establish standards and frameworks surrounding this issue for broad application.

Beneficiaries of this work are numerous and span the mining industry, including mine workers, mine operators, equipment developers, and government agencies. Mine workers could be injured, face health hazards exposure, or be involved in a mine disaster due to a malfunctioning piece of critical safety or health equipment. Mine operators seek to safeguard against EMI-related equipment malfunction. Equipment developers seek to ensure EMC for their products. Lastly, government agencies seek to write and enforce science-based regulations.

Dr. Schafrik asked if researchers are compiling the frequencies that devices are both susceptible to and frequencies are releasing, noting that the frequency that triggered the gas monitor is a common radio frequency and could impact the gas monitor calibration process. Dr. Zhou responded that testing for susceptibility scans a wide frequency range, including the 900-megahertz frequency used for the IWT radio system underground, and involves finding the threshold level, the energy level that a device can withstand without an impact, over that spectrum, developing a susceptibility curve. Mr. Bowersox asked if coal seam height has a bearing on interference; Dr. Zhou noted that a coal seam doesn't generate EMI but, as a propagation environment with reflection or deflection of wave travel, it might cause a passive impact. How significant that impact might be really depends on a particular case. Mr. Stewart asked what role the Federal Communications Commission plays in these types of issues and if the issue can be pushed back on the manufacturers; Dr. Zhou responded that the FCC regulates the maximum energy that a device can emit, but, as long as there is no surface impact, they don't regulate underground emissions. Ms. Calhoun asked about mitigation methods to lower the interference; NIOSH research has looked at several methods, each with their own advantages or disadvantages. Distancing is the easiest of the things to do, but when miners are focusing on their work, they might not pay attention to the distance. With shielding, there is additional weight and cost. Filtering requires a system redesign and the addition of an EMI filter to change the emissions; for underground coal, that would require MSHA recertification. Ms. Calhoun then asked about the impact of a change for the Thermo CPDM to lithium-ion batteries; Dr. Zhou noted that when current goes through a battery, there are emissions, but that it can be generalized, rather than related to a specific battery chemistry.

Dr. Luxbacher then offered some additional comments. NIOSH is currently funding Thermo on a redesign of the CPDM, however that is still probably four years away from the availability of the next-generation CPDM. An interim unit may come out sooner because some of the components used are technically obsolete and must be replaced, and that unit may utilize a lithium-ion battery. With regard to ownership of the emissions and susceptibility issue, each manufacturer sees those as the other product's issue, which makes resolution difficult without regulations as exist above ground. NIOSH is currently working with JPL on the development of a design for a magneto-electro quasi sensor (MEQS) for proximity detection which may be less susceptible to interference; this demonstrates how we get synergy between different projects since, after an introduction to JPL during the DARPA Sub-T Challenge run at PMRD, we're also actively working with JPL on a permissible mine rescue robot design. Dr. Luxbacher also noted that NIOSH is interested in EMI from the standpoint of automation, given the potential for EMI to disrupt operations. The number of emitting sources underground are going to continue to grow, and NIOSH is committed to work in this area at both PMRD and SMRD.

Mitigating Fire and Explosion Hazards of Lithium-Ion Batteries (9390BMN)

Thomas Dubaniewicz

For the Mitigating Fire and Explosion Hazards of Lithium-Ion Batteries project, researchers characterized lithium-ion battery fires to determine appropriate fire suppression agents. Water was found to be the most effective fire suppressant, but large amounts of water are needed. Dry chemical and class D extinguishers may put out the fire temporarily, but reignition can occur. A publication discussing the research towards these issues has been recognized with Alice Hamilton Award Honorable Mention.

Researchers characterized thermal runaway pressures and explosion-proof enclosure volume dependencies. An inverse power relationship was observed for thermal runaway pressures and enclosure free space volume. The data supports recommendations to provide adequate enclosure free space, prevent thermal runaway cascade, or provide enclosure venting with flame arrestor. There are two technology development contracts for cell isolation materials and flame arrestors. A publication discussing this research was recognized with a Public Health Service engineering literature award.

Researchers are engaging stakeholders at mining operations, universities, equipment manufacturers, industry associations, and the Mine Safety and Health Administration (MSHA). An industry association has recommended practices for battery electric vehicles that reference several NIOSH-authored publications. Findings from NIOSH research support an international safety alert for flame-proof enclosures, and following recent research and recommendations, equipment manufacturers are reassessing explosion-proof battery designs. These findings continue to be disseminated and were recently presented at a university sponsored workshop and a graduate mining engineering seminar.

At the conclusion of the presentation, Ms. Calhoun thanked Mr. Dubaniewicz for training presentations he has given for MSHA employees. Dr. Luxbacher then mentioned that the Mining

Program has been in discussions with several companies that utilize batteries underground. At one mine, filter self-rescuers were being used and our researchers pointed out that these FSRs are only useful against carbon monoxide, not the toxic fumes potentially emitted during a battery fire. The difficulties on extinguishing battery fires are significant. There is a great need for further research and input to guidelines. Ms. Pritchard then asked if NIOSH was working with national groups related to extinguishing fires. Mr. Dubaniewicz responded that a fire extinguisher that's snuffs out a fire by depriving of atmospheric oxygen, so that it doesn't work very well when the battery provides its own oxygen source. Consequently, dousing a fire with as much water as possible to facilitate cooling appears to be the most common way of approaching these fires right now. With the large batteries that will be used in mining equipment, they are well protected, and it will be difficult to get water directed where it is needed, and the quantity will be large. Dr. Luxbacher then mentioned that, while battery use will grow significantly, diesel powered equipment will continue to be utilized in mining for a long time; a hydrogen-powered haul truck is being piloted by Anglo American in Africa, so the Mining Program is also looking at the issues associated with hydrogen fuel cells.

Improving Prevention and Suppression of Diesel-Powered Equipment Fires in Metal/Nonmetal Mines (9390DTK)

Dr. Davood Bahrami

This project is addressing the need for scientific-based data on equipment fires caused by hot surface ignition and effective fire suppression systems. The research employs an experimental approach to investigate the main variables affecting hot surface ignition as well as the efficacy of available fire suppression systems. The research also investigates post-fire effects of equipment fire on mine ventilation as part of developing a mine ventilation diagnostic tool.

Researchers have completed experimental tests to provide the much needed scientific-based data on the hot surface ignition and the effect of controlling parameters such as air speed, fuel type, and surface material. The results indicate that fuel type has a major impact with ignition probability being highest for (1) diesel fuel, followed with (2) engine oil/hydraulic fluid. Metal type has some impact with ignition probability being highest for (1) stainless steel/cast iron, followed with (2) carbon steel. The data helps with the detection of hot surface temperatures if it is close to ignition which will help with fire suppression system design. The results have been published and will be used by stakeholders, such as Mine Safety and Health Administration (MSHA) Approval and Certification Center (ACC). A Pittsburgh Mining Research Division (PMRD) fire facility is set up with a fire suppression system evaluation apparatus to study five different fire suppression systems such as water mist, dry chemical, dry-wet chemical, wet chemical, and CO2.

Researchers developed a machine-learning based model to predict fire size and location. They are also working on development of ventilation network diagnostic tool for abnormal airflow. Hot surface ignition results could be used by MSHA for providing technical support to mines. Fire suppression manufacturers could use the results to improve suppression system design. Mine operators could benefit from the Machine Learning-based diagnostic tool.

Integrated Analysis of Coal Pillar and Entry Stability (9390DTL)

Dr. Khaled Mohamed

A recent study conducted by NIOSH for a period from 2010 through 2019 shows that 120 fatalities occurred in UG coal mines; 26% of these fatalities are caused by ground-fall incidents and 80% of these ground-fall fatalities are caused by roof and rib falls, including two fatalities in the past two months that occurred due to roof and rib falls in underground coal mines. This project aims to eliminate these types of roof and rib falls in underground coal mines by developing an integrated system for the design of pillars, roof, and ribs.

Project accomplishments to date include the development of gateroad and rib stability analysis software tools. The gateroad stability and rib design software represents individual components of what is intended to become the Analysis of Coal Pillar and Entry Stability (ACPES) software. The gateroad stability analysis, currently in spreadsheet form, allows the user to calculate the factor of safety of supported/unsupported mine roof based on the regression analysis of numerical modeling results. The Design of Rib Support (DORS) software currently provides the user with a Coal Pillar Rib Rating (CPRR) based on the regression analysis of numerical modeling results and a recommended minimum primary rib support density based on surveyed ribs. NIOSH ground control applications suite are known for mining industry which include ALPS, ARMPS, ARBS, and STOP. None of those applications can be used for rib design, and DORS should be able to fill this gap.

The project has various interactions with interested parties. The gateroad stability analysis software is currently in its beta version and is being evaluated at multiple longwall mines. Support alternatives were evaluated at a northern Appalachia underground coal mine in which headgate roof failure was encountered in a geological transition area. The software was validated by showing a low factor of safety at transition geology area using the default roof support design. The software showed the need for adding a supplementary roof support to cope with the transition. The new roof support designed was successfully implemented by the mine. A workshop was held at a southern Appalachia underground coal mine during the planning stage to evaluate support alternatives for different geology and panel orientations that would be experienced at the mine. The proposed roof support designed was successfully implemented by the mine. Additionally, the Coal Pillar Rib Rating (CPRR) was adopted by the University of Missouri Science and Technology through a project funded by the Alpha Foundation. The CPRR is the basis for rib support analysis utilized in the DORS software.

This project intends to put a new tool in the toolbox of mine managers, mine engineers and geotechnical professionals that will result in more efficient mine design using sound and engineering-based guidelines. For the next 2 years, we are going to work to promote for the developed software among the industry and be sure they are applicable and meet the need of our partners and interested parties.

At the conclusion of Dr. Mohamed's presentation, Dr. Luxbacher mentioned that researchers at Missouri University of Science & Technology have expanded Dr. Mohamed's work under an Alpha Foundation grant, demonstrating the synergy between researchers and the relevance of this work.

Improving Mine Ventilation and Reducing Contaminant Exposure in Large-Opening Stone Mines (9390G0T)

Vasu Gangrade

The project addresses the unique set of challenges in underground stone mine ventilation that arise due the large size of underground openings. First, moving adequate ventilation airflow volumes can take many hours. Second, controlling and directing airflow in these operations is through momentum of the mine airflow rather than differential pressure in the mine openings, due to the low ventilation pressures encountered. The third issue is ventilation system planning. As the operation grows, managers typically work multiple face areas along the perimeter of the mine and, consequently, maintaining a ventilation system is complicated by using multiple booster/auxiliary fans, main fans, and impacts of natural ventilation pressures.

One of the most recent milestones achieved by the project team is the launch of the Air Quantity Estimator (AQE) 2.0 software. The AQE software is helping the mine operators predict the mine airflow to maintain statutory DPM levels. The software has an easy-to-use interface based on spreadsheets, resulting in a short learning curve for busy operators. The unique addition to the software from the previous version is a database of over 40,000 diesel engines from EPA and MSHA databases, from which the engines can be directly selected by the mine operators. The software helps the mine operators in short-term to long-term mine planning. While we only launched this software in January 2022, it is already being using in 9 countries. The word was spread through social media channels and on the NIOSH Mining website.

When the project was first conceptualized, there was a large amount of field travel planned for the first two years. However, even with the start of the project during COVID-induced travel restrictions, and hesitancy that came with it, the project team collaborated with mining companies remotely. The cooperating mine operators supported the project during the pandemic phase by conducting detailed mine ventilation surveys and sharing critical data with the project team.

Ventilation surveys have been performed by conducting detailed computational fluid dynamics studies using the ANSYS fluent software. One of the recent findings that was published in the SME conference dealt with optimized fan placement. Utilizing the fundamental concepts of air entrainment and air recirculation, we were able to increase the net effective ventilation flow rate by 2.5 times and reduce the recirculation by 26%.

In addition to the field studies and numerical modeling work, the project is also developing engineering controls through laboratory work which will be extended to the field later this year. We are working on an auxiliary fan air-filtration system that will help in ventilating dead-end entries and working faces with high contaminant levels. We finished the refurbishment of an old

Spendrup fan that NIOSH owned from a past project. We are conducting performance testing in the lab right now and have established contacts with two mine operators where we can test the air-filtration system.

Currently, there are two PMRD projects that are solely focused on stone mines, this project and a ground control project. As part of our collaboration with the ground control project, we studied the air blast resulting from a massive pillar collapse at the Crab Orchard mine. One of the questions that regulators and the mine operator asked was the velocity of the air blast. Using the CCTV videos and analyzing them using an optical flow algorithm we were able to deduce the air blast velocity as 102 mph. This research is ongoing and one of the potential solutions to the air blast problem is having multiple ventilation raises in the mine, however, we are exploring the research question further using CFD modeling. This work was presented to the Stone Mine Task Force, which consists of multiple state and federal agencies and mine operators.

This research has been conducted in collaboration across PMRD with teams and projects in different research areas, across NIOSH Mining with researchers at SMRD, with other local, state, and federal government agencies, academic institutions, and mining industry operators. The project has made significant progress throughout its life, which would not have been possible without the support of this wide array of collaborators.

Dr. Schafrik asked if there were any plans to validate the CFD with field work using equipment such as smoke tubes; Mr. Gangrade responded that researchers had done that in April, although that type of quantification is difficult in the large openings. Dr. Brickey asked about the origin of the data in the library of equipment for the AQE; then data came from the EPA database of about 65,000 diesel engines and MSHA's with about 500. Mines don't always use MSHA-approved equipment; instead, they often purchase construction equipment. The EPA database also required significant clean-up, including removing outliers. Dr. Luxbacher noted that Mr. Gangrade' s presentation is an excellent example of the benefits that the Mining Program has seen moving to the matrix management approach, with cross-branch and cross-divisional collaboration, as well as collaborations with our extramural contractors.

Development of Engineering Guidelines for Shale Gas Wells Influenced by Longwall Mining (9390G0U)

Dr. Wen "Daniel" Su

This NIOSH Gas Well Project was created to address two major mining safety and health issues: (1) Under a given geologic and mining condition, will longwall-induced gas well casing deformation and stress lead to gas well casing breach and intrusive shale gas? and (2) With intrusive shale gas, what are the impacts on modern day longwall ventilation system and what are the mitigation measures to minimize such impacts? The research approaches adopted include field instrumentation, 3D modeling, physical modeling, and laboratory measurement.

Significant scientific insight and accomplishment from this project to date include, on the ground control side, having conducted numerous 60-arm Caliper surveys, having evaluated numerous mine-by cases, and having identified critical parameters affecting gas well casing stability. These accomplishments have led to the creation of ground control guidelines, which were requested and

presented to NIOSH stakeholders, including MSHA, PADEP, WVDMS, OHDNR, and coal and gas industries, on March 24, 2022. On the ventilation side, we have conducted numerous permeability measurements to evaluate longwall-induced permeability changes, conducted numerous inflow and gas transport simulations to evaluate potential shale gas inflow/migration, and assembled a comprehensive gas compositional database to enable coal operators to quickly identify potential shale gas inflow. These accomplishments have led to the creation of ventilation guidelines, which were requested and presented to NIOSH stakeholders on March 24, 2022.

The NIOSH Gas Well Project places tremendous emphasis on stakeholder interaction and collaboration. We have monthly interactions with our stakeholders, including MSHA, PADEP, WVDMS, OHDNR, and coal and gas industries, to reinforce stakeholder cooperation and participation, and to understand stakeholder issues and needs. This NIOSH project is truly a cross-team, cross-branch, cross-division, cross-agency, and cross-industry project. Most importantly, placing emphasis on stakeholder interaction and collaboration has led to full access to mine-by data, access to coal/gas operations, and important venues to timely disseminate research results to stakeholders.

Research results from the NIOSH Gas Well Project constitute the primary inputs to federal and state regulatory guidelines. This NIOSH project provides critical scientific data and engineering guidelines to our stakeholders on a regular basis. In particular, research results from the NIOSH Gas Well Project provide the primary inputs to MSHA Risk Matrix and PADEP Technical Guidance Document. NIOSH is the only organization in the US and in the world engaging in this very important research to safeguard miner safety and health. In other words, research results from the NIOSH Gas Well Project can be applied to anywhere in the US and in the world, where coal and gas reserves overlap.

At the conclusion of Dr. Su's presentation, Chair Zimmer asked how many wells overlap with the coal fields; Dr. Su responded that it is between 1,500 and 1,550. Ms. Calhoun asked about well types and it was noted this shale gas wells because of the gas volumes and pressures involved.

Methods to Reduce Potential for Massive Ground Collapses in Underground Stone Mines (9390HU8)

Nicole Evanek

Several massive ground collapses have occurred over the past decade and four massive ground collapses have occurred in the past two years. Each massive ground collapse has unique factors. The main objective of this research is to identify influencing factors contributing to a massive collapse, assess the importance of each factor, and improve engineering interventions for those factors. The work will ultimately aid in developing a structured process to examine hazards unique to a site and to consider prevention controls to lessen the risk associated with massive ground collapses.

Project accomplishments to date include collecting and analyzing 3D LiDAR scans for change detection, producing preliminary models generated for two case studies, and identifying leading

factors causing massive ground collapses. These accomplishments are significant, because they have helped one operator determine that a pre-existing massive ground collapse has not continued to fail, they have helped improve future pillar designs, and they have improved our understanding of geologic influences of massive ground collapses.

The project has had numerous involvements with interested parties, both industry and regulatory. Collaborations with Pleasant Gap Mine provided information through 3D LiDAR scanning and site-specific models that helped the mine to better anticipate ground control issues that could cause massive ground collapses. Interactions with Torrance Mine which provided information through 3D LiDAR scanning and site-specific geologic assessments have helped to confirm causes of massive ground collapses and helped the mine take steps towards recovery. Relationships with MSHA have assisted with understanding fatal incidents and have provided technical guidance for pillar collapse initiative. Lastly, involvement in the Stone Task Force has provided technical guidance through 3D LiDAR scanning, site-specific modeling, and the use of S-Pillar to evaluate pillar stability.

This project intends to publish technical papers as specific milestones are achieved. Progress will be communicated to enforcement agencies, mine operators, unions, safety professionals, academia, and crushed stone associations through meetings, briefing reports, technical papers, and peer-reviewed articles. Practical recommendations and ideas will be shared at the Annual Underground Stone Safety Seminar, International Conference on Ground Control in Mining, U.S. Rock Mechanics/Geomechanics Symposium, and the Society of Mining Metallurgy and Exploration Annual Meeting which primarily focuses on mine operators. Publications summarizing design recommendations to reduce the risk of massive ground collapses will be published as a final output.

Dr. Schafrik noted that after closure many of these mines switch over to commercial entities (storage and other uses) and data may be available about collapses at these locations as well. Dr. Biscontin asked if there has been a study of potential instrumentation that can monitor some features of these pillars, referencing a NSF-sponsored project that is looking at vibrations and how the ground responds to ambient vibration. Ms. Evanek responded that the project has collaborations with one mine in particular that has a slow-moving collapse where they utilize the Miner's Helper Extensometers (roof monitors that activate a reflectorized rod when a user-defined amount of movement has occurred) and sensors that monitor sound waves. Ms. Calhoun asked about benching and legacy areas of the mine. Benching is one of the factors being considered under the project. The 3D LiDAR scans pick up the dimensions of the pillars accurately, even in legacy areas, and permit analysis using S pillar.

Human Systems Integration Branch

Inexperience as a Contributor to Workplace Injury (9390BMH)

Dr. Launa Mallett

When miners first enter the industry, when they move to a different mine, and when they take a new type of job, they are at higher risk of injury. We are learning about this risk and seeking ways

to mitigate it. One way we have looked at the relationship between risk and inexperience is by analyzing ten years of data about fatalities. We found that there were considerably more fatalities in the category covering the first year of experience than in any other experience category. This pattern exists for total mining experience and experience at the mine where the fatal injury occurred. A similar pattern is found when looking at experience at in the activity being done at the time of the injury and experience the job.

We are also looking at data related to experience and nonfatal days lost (NFDL) injuries. In 2008 and 2018 NIOSH conducted surveys of the industry that included questions about experience levels of miners. We can use information from the surveys and NFDL numbers to calculate injury rates for miners with specific levels of experience. The 2018 rates show that the least experienced miners were at the highest level of risk of injury. That confirms what we found with the 2008 data and is an issue across all mining sectors. We are still analyzing this data.

Our analyses of the injury data showed there is a problem, but we have also uncovered some good news. We conducted interviews with safety and health professionals, trainers, and human resources staff at five mining companies to find out what policies and practices could be impacting the new employees or employees moving to new parts of their organizations. Some of the companies were thinking ahead to enhance and expand their hiring pool. For example, some companies are working upstream with high schools to enlarge and to enhance the knowledge and skills of potential employees in the hiring pipeline. Others were trying to improve strategies for learning and had created dedicated training space that included options for hands-on time with equipment. Companies were assessing worker competencies and making training needs visible. One had created a system to track competency assessment results for all employees so they could always know who is qualified for what jobs. And companies were building social bonds to support learning and communication with policies like onboarding only once per month, so it is a uniform group experience for each cohort of new employees. We are still asking questions and will share the ideas so others can try the ones that fit their organizations.

We have started sharing what we have learned about risk and inexperience. Presentation and workshop participants have been very interested in the topic. We are working on sharing information in ways it can be used by the industry and plan to create a project website to make our findings easy to find. During a couple of workshops that we conducted, participants worked through how people in various roles at their organizations could improve safety and health of inexperienced workers. They were guided to come up with specific actions they would take.

This presentation elicited a lot of interest from the Committee. Ms. Brickey highlighted the potentially high impact of this research and then asked if experienced miners changing jobs was being considered. Dr. Mallett responded that the survey data and the injury data look at ‘new to industry’, ‘new to mine’, ‘new to job’, and ‘new to activity’; the results definitely show a correlation for first year, and the data for the second year is still being evaluated. Ms. Prichard noted the importance of this work, particularly from a workforce development perspective and encouraged the Mining Program to continue this research. Dr. Mallet and her team plan to get back into the field and do some follow-up and are interested in increasing the competency of new hires. Chair Zimmer asked if the researchers have looked to other industries’ their training programs and

how they bring people into work, for instance, in the construction industry; the building trades across the country have all types of programs set up, including workforce development, people opportunity, and apprenticeship. He then asked about the impact of age; the response was that age does correlate with the 'new to industry', but it doesn't correlate with the 'new to mine', for example, because this represents experienced people moving to different positions. With or without the age component, the same experience issue is seen. Chair Zimmer added that in the new construction industry, when labor was promoting training programs, the return on investment had to be shown, relating the money spent on training to increased productivity and enhanced safety. Mr. Moore reemphasized the value of this work, noting how important this is particularly in the coal industry where hiring is now taking place after a ten-year break; he noted that the time requirements vary between states from 6 to 12 months to be considered an experienced miner, but the time is never broken down by activity. If an individual does the same job continuously for the required training period, they can suddenly be thrust into another position as an experienced miner without appropriate training. Consequently, his company has put together a loop program to track these individuals during the training period to make sure they're getting certain segments of training throughout that period rather than just one task exposure. In response, Dr. Mallet planned to add that to the list of concepts companies are utilizing. She also added that while reviewing the 2008 data, which we had adequate detail to separate out the first six months from the second six months, the team identified a 'notch of safety'. The rates for first six months were quite a bit lower than the second six months, and the researchers feel it was for the reason Mr. Moore mentioned: during the first six months the employees were subject to more supervision while during the following six months they were given more job responsibilities with less supervision. Mr. Bowersox mentioned that when he started working in underground coal, an individual worked with the same crew for years, always having someone overseeing what was being done and, in effect, functioning as a continual training process. Dr. Mallet noted that, in one of the cases in this research effort, trainers were formally assigned, and it was made a formal part of their job duties.

Characterization of Haul Truck Health and Safety Issues & Virtual Reality Mine Rescue Training (9390C9W)

Jennica Bellanca

Characterization of Haul Truck Health and Safety Issues

This research project started in 2019 and is planned to continue until the end of fiscal year 2023. The project is designed to help identify why haul truck accidents and injuries keep occurring. The project is structured to take a more holistic look at accidents and injuries, technology, and issues directly facing mineworkers.

The first part of the project was to develop a roadmap to inform the direction of future health and safety research related to haul trucks. To develop this roadmap, researchers met with interested parties (stakeholders), reviewed previous research, and analyzed fatal accidents to identify key areas of concern. Overall, the report found that a systems approach is needed to fully implement any new or previously tried solutions across all areas and levels of the mining system. As a result

of the roadmap, several projects and activities have begun such as the NIOSH collision avoidance and warning systems validation project.

In looking at technology related to haul truck health and safety, specifically collision avoidance and warning systems (CXS), researchers found that more validation work was needed. Researchers performed a systematic review of the peer-reviewed CXS literature to evaluate the maturity level of the technology (1 = idea to 9 = common product) over the last 20 years (2000 – 2020). Given that a level 7 indicates mine implementation, there was not that many examples of commercial validation. However, we know commercial products have been on the market since before this time. Therefore, partnerships on validation work would help ensure that these products can be evaluated in a standardized fashion and truly function as marketed to keep mineworker safe. We encourage more industry, academia, and government collaboration and a greater effort to publish this work to ensure that the results are reaching the public.

The last part of the project involves interviewing mineworkers that work in and around haul trucks including haul truck operators, managers, trainers, health and safety professionals, and maintenance professionals. Researchers have interview 97 mineworkers from surface mine sites of various commodities from the Eastern and Western United States. This work is allowing researchers to understand the differences in perspectives and identify opportunities for improvement. The mineworkers shared near miss incidents as well as perspectives on hazards, training, and expertise.

From this work, we are providing the industry with lessons learned and tools they can use. For example, we are developing simulation videos of near misses that provide mineworkers with a first-hand account of something that really happened to provide a safety message such as: it is critical to communicate and check your surroundings, maintaining situational awareness can save your life, and small hazards can lead to fatal accidents.

Virtual Reality Mine Rescue Training

NIOSH has partnered with the Mine Safety and Health Administration (MSHA) to develop a virtual reality (VR) training system to improve mine rescue team members' procedural, collaborative, and problem-solving skills for an underground emergency response. VR Mine Rescue brings realism and collaboration to mine rescue training to enhance team readiness.

VR Mine Rescue includes critical tools and tasks such as mapping, sounding the roof, date and initial among others. VR Mine Rescue also allows team members to interact with dynamic airflow and ventilation through real time measurements, similar to what they have during a real emergency, using a smoke tube or gas meter. Use of these simulated tools provides more realism versus using a placard on the ground typically used during traditional in-person contests. The dynamic ventilation parameters and feedback changes with changing mine conditions based on the action that team members take, for example, hanging a curtain to direct airflow.

The video shown in the presentation demonstrates what this experience looks like as a team explores an intersection. VR Mine Rescue allows user to participate in a co-located space as well as remotely with individual team members located in separate locations.

VR Mine Rescue also includes a debrief functionality. The software records team member actions and events and includes the ability to debrief afterwards. Team members can go back through the simulation afterwards and see: 1) where and how far they explored and 2) what actions were taken when and by whom. They can use this information to discuss the decisions they made. The debrief in VR Mine Rescue also allows team members to see how they performed actions like sounding the roof with a 3D playback so that team members can understand how their actions resulted in changes to the outcome of the simulation. Lastly, the debrief in VR Mine Rescue allows team members to review the situation as a whole, visualizing the changing environment such as CO or methane levels to facilitate a broader understanding of how the problem unfolds and the results of their actions.

The next steps for this work are to demonstrate and evaluate the VR Mine Rescue Training systems at various training events including the International Mine Rescue Competition. After the demonstrations the system will be deployed at MSHA's academy in Beckley, WV.

At the conclusion of the presentations, the Committee asked questions about both the haul truck and VR work.

Haul Truck Health and Safety Issues

Mr. Stewart asked about the scope of the haul truck project; Ms. Bellanca explained that the project began with a literature search going back 20 years when there were few collision avoidance warning systems available for validation and little published; she also noted that, with current systems, it still takes a long time to get the data out and published, creating a time lag. The research utilized peer reviewed data, while work done by entities such as EMERST and ICMM goes out to their stakeholders, but it doesn't go out to the whole industry necessarily and wouldn't be included in the literature.

Virtual Reality Mine Rescue Training

Mr. Moore congratulated the team on the progress they have made with the VR work over the earlier iterations, noting that the current version is very impressive, and industry now has that can move forward and help in mine rescue training. Mr. Bowersox also complimented the team and asked if this product will be available at the MSHA Mine Academy for training; he was told that was the intent and that a demonstration was planned for the International Mine Rescue competition in September. Ms. Calhoun then noted that MSHA is strongly in support of the VR work and plans to have it at the Academy.

Human-centric Lighting (HCL) to Improve the Health, Safety, and Well-being of Underground Miners (9390DTM)

Dr. John Sammarco

Underground miners, especially those working shifts, have significant disruptions in the natural day/night cycle of light exposure which disrupts their circadian rhythms. Circadian disruption can result in sleep loss, reduced alertness, and can increase risk of accidents and health problems that

include obesity, diabetes, and cancer. This project uses the intervention of human-centric lighting (459 - 484 nm light that has a biological effect on humans) to reduce circadian disruption and reduce the associated health and safety risks. We are investigating wearable lighted eyewear intervention worn during pre-shift. The second intervention will be machine mounted HCL used during the shift.

We have several accomplishments that are on the critical path for stakeholders to successfully use the primary project outputs that are: 1) wearable HCL intervention used above ground before the shift starts and a machine mounted HCL intervention used during the shift. For our interested parties, it is important to ensure field data support human-centric Lighting efficacy if human-centric lighting is to be used for improving the safety of mine workers.

We have completed four critical milestones to obtain field data establishing the efficacy of human-centered lighting to improve safety. These include 1) selecting lighted eyewear for pre-shift intervention, 2) establishing pre-shift data sources and data acquisition methods, 3) developing pre-shift miner training, and 4) completing machine-mounted human-centric lighting simulations. The expected benefits of this research include better sleep, reduced fatigue, increased alertness, reduced errors, improved hazard detection, and reduced health risks.

At the conclusion of the presentation, Dr. Brickey complimented this research and noted its applicability in surface mining, especially in the north where a miner a 12-hour night shift when the sun doesn't come up until 8 to 9:00 am and sets at 3 to 4:00 pm may not see daylight until they have a day off. She then asked if the research has looked at the mental health aspects, including seasonal affective disorder just from living in northern areas. Dr. Sammarco responded that our research has not looked at mental health impacts, but other studies have demonstrated them. Mr. Stewart asked what outcomes or analytics are being measured. Dr. Sammarco explained that core body temperature is measured because that is indicator of melatonin release; the body is sensitive to blue light. As melatonin goes down, core body temperature goes up, providing data demonstrating impact. With some of the surveys using the Actiwatch, both sleep and activity data are tracked. Standardized surveys like the Pittsburgh Sleep Quality Index (PSQI) and the Karolinska Sleepiness Scale (KSS), are being used. The NASA PVT (Psychomotor Vigilance Test) app, which tests reaction time, is also being used. Chair Zimmer expressed that the construction industry would benefit immediately from this research, given the issues with night work.

This concluded the presentations for the first day. Both Dr. Sawyer and Chair Zimmer thanked the Committee for their interest and input.

Close

Wednesday, May 18, 2022

DFO, Announcements, Roll Call, Chair Remarks

At the start of the second day of meetings, Dr. Luxbacher took roll call and all members other than Dr. Mattson were present. Chair Zimmer welcomed the Committee and members of the public. He then turned the meeting over to Dr. Howard.

NIOSH Director's Remarks

Dr. John Howard, MD

Director

National Institute for Occupational Safety and Health

Centers for Disease Control and Prevention

Dr. Howard thanked the members of the Committee for taking time to participate in the Advisory Committee for the mining program and expressed his appreciation.

He then gave an update on the subvariants of the Omicron SARS-CoV-2 variant. While these subvariants are transmissive, they are not as virulent, although they evade both vaccine-based and natural infection-based immunity, which leads to possible reinfection. Despite this NIOSH researchers have begun to return to the labs and physical workspace and field investigations restarted in April. Through HHS, CDC, and OPM, the Office of Personnel Management, our employees have been allowed to have remote working arrangements, remote working within the commuting area where they may be, or even beyond the commuting area, as well as more flexible telework agreements; the nature of the workplace has changed due to COVID-19.

Dr. Howard then discussed the NIOSH budget. NIOSH received $351,800,000, an increase of $6.5 million over the FY2021 enacted level. Most of that is for extramural program: the Education and Research Centers got $1 million, the Ag, Forestry, and Fishing Centers got $1 million, the Total Worker Health Centers got $1 million, and personal protective technologies got a $2 million increase and was directed to provide a report about how technology, including voice-activated technology, could save PPE and healthcare workers, clinicians' lives.

Dr. Howard then concluded his remarks and asked if there were any questions.

Matt Stewart, asked about the impact of COVID-19 on pulmonary function, noting the vaccine hesitancy among miners and the possible future impacts. Dr. Howard responded that this is related to long COVID and that a lot of research funding is currently directed toward long or chronic COVID, trying to establish the prevalence and how they are affected. It is a multi-system-type disease, including effects on lung function. Regarding a worker who may be suffering from long COVID and asking for reasonable accommodation, one of the medical issues is to be able to do, like we do with noise, some type of baseline assessment of lung function (lung function tests or PFTs) as they return to the workplace, so there is some attribution to cause.

Chair Zimmer thanked Dr. Howard for his work on the opioid crisis and all the research that the NIOSH staff has been doing. He noted he, as the Health and Safety Director for the Operating Engineers, Local 478, is an end user of these programs, has seen the educational, the awareness programs that have been developed by NIOSH, and it's removing the stigma and making a difference in the addiction issues, suicide, and mental health. This ties with the total worker health concept. He noted that there is crisis within a crisis: illegal and illicit drugs being taken with fentanyl. He feels that educational programs are required to raise awareness for workers across the country that there's no such thing as a recreational drug anymore; workers are dying at an alarming rate with one-time use. This could be a layer added to the baseline of work related to the opioid.

Dr Howard responded by thanking to all of the NIOSH extramural partners, especially CPWR, that contributed to this area and utilized NIOSH resources. He noted that the issue of fentanyl-laced drugs is so pernicious; tablets that look like Tylenol, laced with fentanyl, are now available on the street, made in pill imprinting machines that you can order online on the internet. Last year there were 107,000 related fatalities, more than any year before. The problem is not going away, and close attention needs to be paid to it.

National Personal Protective Technology Laboratory (NPPTL) Overview

Dr. Maryann D'Alessandro

Director of National Personal Protective Technology Laboratory

Dr. D'Alessandro noted that it had been three years since she had an opportunity to update the Committee on the work at NPPTL. NPPTL is the division within NPPTL that focuses on personal protective equipment research, standards development, and the respirator approval program. Operations are split between Pittsburgh and Morgantown with staff in both locations. The Mining Program is supported through the escape respirator approvals, the long-term field evaluation, and the breathing air supply research.

With regard to escape respirator approvals, these are done under Subpart O. Subpart O was developed over about 10 years, from the early 2000s to 2012. When that subpart approval came into effect in 2012, manufacturers had some difficulty in obtaining approvals. Approvals were more difficult that suggested through research and prototyping that had been done. Consequently, Subpart H units were allowed to stay on the market past a planned sunset date for one-hour devices in 2017 and 10-minute devices in 2016. While several Subpart O devices were approved, some of those approvals were rescinded and a final guidance was issued in June 2019 stating that the manufacture, sale, and labeling of those products developed under the Subpart H could continue to remain in the mines, however, they could not be modified. There do not have any date at this time at which time those units will come out of the mines.

Currently there are four Subpart H units that are in the mines, three 60-minute units, two of which are belt-wearable, and one 10-minute belt-wearable unit. The primary issue with the Subpart O units is that additional requirements resulted in those units being a lot larger and not be belt-wearable for the CAP 3 units, analogous to the 60-minute units. Under the Subpart O

requirements, two devices are currently approved, both are under Ocenco. One is the EBA 75, a CAP 3 (analogous to the 60-minute rating), and the other is the M20.3, CAP 1 (analogous to the 10-minute rating). Two other approvals have been rescinded, an Avon Corporation CAP 1 unit that was never used in the mines and a CSE Corporation CAP 3 unit. Currently the MSHA inventory shows there are about 197,700 escape respirators deployed, and only 2.8 percent of those are Subpart O units under the new standard.

The long-term field evaluation (LTFE) program was established over 20 years ago, and initially it was developed as a research program to look at a random sample of units to see how the units performed when they came out of service in the field. Initially 100 of every model that was in use in the mines was evaluated. This approach required a long time to complete the work and publish the results. In the current strategy, both Subpart O and Subpart H units are evaluated under both a conformance and a research component. The conformance component looks at the Subpart O devices similarly to how the devices are approved, using the same equipment. The research component is looking at both Subpart O and Subpart H units from the same mine and hopefully used in the same way, whether they're carried, used on mobile caches, or stored in the static caches. The intent is to do a comparison and provide information to improve the standards in the future.

Under the current LTFE, the intent was to first look at the CAP 3 units, the SR2000 followed by the EBA 7.5, then the 60-minute units, the 75, and then the CAP 1 M20.3. Unfortunately, this process was initiated during COVID; units were collected from the mines, testing started in April 2020, and then halted, other than some tests done in June 2020. Testing for the SR2000s and the SRLD is completed, but we still are waiting on the EBA 7.5 and M20.3. EBA 75 replacement units were distributed the to the mines, but NPPTL, due to chain of custody issues and the inability of the mines to ship the in-service units, was unable to collect the units required for evaluation.

The report that is under development right now will have 40 Subpart H and 40 Subpart O units, and 40 that were stored in the mobile equipment caches and 40 were carried by the miners. The exposure time for both the Subpart O and the Subpart H units ranged from approximately 11 to 19 months.

With the most published recent LTFE evaluations of respirators were under a previous sampling strategy, evaluating every respirator in use, using approximately 100 of each. Two reports were published several years ago.

The SR2000 and the SRLD are two units manufactured by CSE; the SR2000 was the Subpart O unit, since rescinded voluntarily by the manufacturer and removed from mines, and the SRLD, a Subpart H unit that is still in the mines. Forty of each were collected from mines and the forty SR2000 units were tested on the ABMS; for the SRLD, there were six that did not pass visual inspection, so were not able to be tested. That report on the evaluation of these two units has been drafted and is currently in peer review, with a planned publication in the fall of 2022.

The EBA 75 units have been sent to the mines; collection is planned for this summer, with testing through the rest of 2022; the report should be published summer 2023. The next group of units for testing are the Ocenco M20 and 20.3 units, and those will be collected in early calendar year 2023 and tested throughout third quarter of 2023 and a report published in 2024 timeframe.

The third area where NPPTL supports the mining program is in the breathing air supply research. After the new standard (Subpart O) was established, PMRD initiated this breathing air supply research effort to develop components that would improve upon the current designs of self-contained/self-rescuers or the closed-circuit escape respirators. The efforts were then moved to NPPTL several years ago, and now they are focused on the development of a liquid oxygen storage module, test docking and switchover functions for a fully functional facepiece and T-Bit mouthpiece, and the oxygen delivery system; as well as supporting PMRD and MSHA in encouraging manufacturers to produce commercially available products.

The liquid oxygen storage module or LOXSM provides an opportunity to reduce the size of future escape respirators. The contract effort for this project ends in September 22, and a determination is underway to decide if publication or further research is warranted.

The NPPTL work has focused on taking risk out of the manufacturer's research and development and promote interest in developing the next generation units by providing designs for components. A Request for Interest (RFI) was put out by the Mining Program with assistance of NPPTL to encourage manufacturers to use the components that have been developed; unfortunately, there were no pertinent responses, but this was put out during the time when the pandemic was the focus of the nation. While it is uncertain if that had an impact, it seems that there isn't much interest by the current SCSR/CCER manufacturers in pursuing this technology any further.

Dr. D'Alessandro then asked the Committee two questions: 1) with the new LTFE focus on the non-cache units, how could that benefit the mining community and 2) relating to the breathing air supply work, how can evidence-based components of prototypes penetrate the market and get integrated into commercial markets.

Mr. Moore pointed out that industry currently has two choices, either use the M20, which has only been rated for 10 minutes, a relatively short period of time, to get to a 60-minute device cache, or belt wear a SRLD rated for 60 minutes. Research to provide a unit that provides more than 10 minutes but is easily belt wearable would be readily accepted. When a miner is wearing a CPDM, SCSR, and other gear, he probably has 12-15 pounds that he is carrying around. His personal preference is for an oxygen-based unit, where a valve is turned on and you have oxygen, as opposed to possibly having possible issues with oxygen generation. Mr. Moore then asked about the validity of a rumor about manufacturer problems in getting devices for the next few months to possibly years. He asked if there was any testing done of extending the life of some of these stored units. Currently, when his company takes units out of service, they are used for training; employees during smoke training each year rather than use a simulator. While, in this way, they get a benefit to the employees from the actual exposure using the expired units, there may be a problem coming up in needing to keep these units in service for a short period of time while manufacturers catch up. Dr. D'Alessandro responded that some manufacturers offer the opportunity to submit a certain percentage of units back for evaluation and reassessment of the service life, however NPPTL is not involved in that process.

Dr. Luxbacher noted that the Mining Program is funding the NPPTL work on liquid oxygen and plans to continue to do so, believing that technology will lead to the next generation of CCERs. He pointed out that the Ocenco 6.5 is a first-generation unit, still in service and use today. While

Ocenco offers the Subpart O 75 unit, there is a need for research toward the next generation units. Given the limited US market and requirements, manufacturers have little interest in major technology changes, as demonstrated through the response to the RFI. There is no doubt that when a miner must switch between units, either 10 to 60-minute or between 60-minute units during escape in an atmosphere that may be immediately dangerous to life and health (IDLH), the docking and switchover valve integrated with a T-bit simplifies the process at a stressful time. Despite that, without a regulatory requirement, there is little interest in the technology. SCSR/CCER manufacturers have different standards worldwide and larger markets, but the U.S. is a unique marketplace, particularly with the requirements of Subpart O. Dr. Luxbacher then highlighted the synergy between the CCER work and one of the U60 grants; the grantee (MUS&T) is interested in communications while wearing a CCER; NPPTL is working with the grantee such that the information will be beneficial to furthering the research of both groups.

Mr. Bowersox then asked about the weight and form factor of the possible Liquid Oxygen Storage Module (LOXSM) units. While the research is in its early sage, the anticipation is a unit the size of the current M20 may provide 40 to 50 minutes of oxygen. While there is industry interest in a CAP-2 unit that bridges the divide from the M-20 to the SRLD, there is no serious manufacturer interest in such a unit for the U.S. market. That was included in the RFI (request for interest), but it didn't result in any responses. Mr. Moore then asked if the current version of the T-DOK still has the bite lug for the person to wear? Dr. D'Alessandro responded that there is a still a bite bit or lug; it must be removed to talk.

Respiratory Health Division (RHD) Overview

Dr. Scott Laney, Epidemiologist

Dr. Laney gave a brief overview of the Coal Workers' Health Surveillance Program, including COVID impacts, recently published findings, and rulemaking related to the B Reader Program. The Federal Coal Mine Health and Safety Act was passed by Congress in 1969 to protect the health and safety of the nation's coalminers, establishing permissible dust exposure limits and empowering NIOSH to conduct routine health surveillance on active coalminers through the Coal Workers' Health Surveillance Program. The act also directs NIOSH to study the causes and consequences of coal-related respiratory diseases and to develop improved health and safety standards to protect the nation's miners.

The primary goals of the Coal Workers' Health Surveillance Program are early detection and prevention of Coal worker's pneumoconiosis (CWP) through surveillance and by providing miners information about their health. The components of the program are X ray screening, spirometry testing, respiratory screening questionnaire, and an occupational history. These exams are conducted at NIOSH-approved clinics near the mine sites and through the NIOSH mobile examination unit. The B Reader Program is a program that assures standardized X-ray readings by physicians. RHD also administers the National Coal Workers' Autopsy Study.

During the COVID-19 pandemic, many of the Respiratory Health Division staff became involved with CDC's COVID response. In addition to the limited staff availability and CDC travel

restrictions, it was felt it was too much risk to be putting miners in the truck and performing breathing tests. All planned surveys for the mobile unit in 2020 and 2021 were canceled due to COVID-19. As the pandemic went on, the RHD outreach project officer developed alternative procedures to decrease possible exposures in the mobile unit in the future by moving some stations outside and having fewer staff and miners inside the mobile unit at any given time. The infection control plan was also updated to include wearing masks and increased sanitation. With the mobile unit out of service, the opportunity was taken to update or add engineering controls to the unit, including a new dual HVAC system, an improvement over the previous single-unit system. The spirometry stations were redesigned to include plexiglass dividers between the technician and the miner taking the test, and an independent HEPA filtration system was built into the counter where the spirometry is conducted. The spirometry stations will also be utilizing new spirometry systems that can use filtered mouthpieces, and software is currently being developed and evaluated for approved use. Ultraviolet-C (UVC) lights, used to disinfect surfaces, were installed in all of the compartments in the exam space in the mobile unit. The ventilation system was assessed in April of 2020, to understand its capabilities, and it performed very well. Although RHD was not able to conduct coal surveys, the mobile unit was deployed to three towns in West Virginia to support COVID-19 vaccine drives for coalminers and their families.

The NIOSH B Reader Program was put on hold during COVID as well; no courses or exams were held, and existing B Readers received six-month extensions from NIOSH throughout the pandemic to maintain their B Reader status. These extensions will continue until the exam is again offered, hopefully later this year. RHD also continue to partner with the American College of Radiology to provide B Reader courses and exams, although none were held during the pandemic; their education center is scheduled to reopen in late August.

COVID also impacted the program work done at NIOSH-approved facilities. Clinics stopped both X-ray and spirometry in March of 2020 as most of the country shut down. X-ray was reinstated in June of 2020 followed by spirometry in May of 2021, if the proper infection control practices were followed and accounting for any local, state, or federal guidelines.

In March of this year, Congress passed the Consolidated Appropriations Act of 2022. Although there is no dedicated funding, the Act directs CDC to prioritize maintenance of the mobile units and urges CDC to consider the purchase of an additional mobile unit, though this obviously would be reliance on future funding. This year two coal surveys are planned, one two-week survey in West Virginia in July, and a two-week survey in Kentucky and Virginia in August. The updated alternative procedures and infection control plan will be used to minimize the risk of SARS-CoV-2 transmission, and spirometry testing is not planned.

The prevalence of coal workers' pneumoconiosis continues to remain elevated in the United States, being driven primarily by cases in Central Appalachia where prevalence in long-tenured coalminers who work underground remains around 20 percent, the highest in 30 years. The most severe form of CWP, progressive massive fibrosis, also remains high among long-tenured Central Appalachian coalminers, at around four percent. Much of the RHD research of underground coalminers has implicated silica exposure for the observed increase in the prevalence and severity of pneumoconiosis.

Recently RHD has turned their attention to surface coalminers. In 2020, 40 percent of the coalmining workforce was comprised of surface miners, and, using MSHA compliance data from 1982 to 2017, the vast majority, 98.4 percent, of the samples collected for respirable dust were in compliance with the two-milligram standard over the majority of this time period. However, the subset analyzed for quartz content exceeded the applicable standard for quartz 15.3 percent of the time. Surface miners were included in included in respiratory health screening beginning in 2014 due to a MSHA regulatory requirement, enabling NIOSH to expand the screening to include all U.S. coalminers and also including spirometry and symptom assessment. Reviewing the data from these first six years, from 2014 to 2019, pneumoconiosis was present in 1.6 percent of surface coalminers, and that included 12 miners with progressive massive fibrosis. Surface miners in Central Appalachia were 4.2 times as likely to have CWP, and surface miners who worked as a driller or blaster were three times more likely to be at increased risk for pneumoconiosis.

Primary prevention efforts are meant to reduce the incidence of disease and include administrative and engineering controls, such as ventilation plans and dust suppression or capture devices, activities enforced by MSHA, and include periodic compliance sampling for respirable coalmine dust and respirable quartz. Secondary prevention efforts are designed to reduce severity of disease through early detection of pneumoconiosis and subsequent job reassignment to a less dusty working environment. This is accomplished through routine radiographic screening in the NIOSH-administered Coal Workers' Health Surveillance Program, and also the Part 90 program established by MSHA, where miners can exercise their right to move to a less dusty part of the mine if they have pneumoconiosis. Though the Part 90 transfer option has been in place for 50 years and miners are informed of this right when they participate in radiographic screening, over 85 percent of working coalminers who have participated in screening and have radiographic findings of pneumoconiosis have not elected to exercise their right to a lower dust environment. Of the less than 15 percent of coalminers who do exercise their Part 90 job transfer option and continue to work, one-third have progression of their disease even though they have transferred.

CWP is a progressive disease and continues to progress even after removal from exposure. Disease progression is not a linear process. It appears to accelerate as the disease becomes more advanced. This makes early detection and early removal, a reduction in exposure, very important and has a variety of policy implications. Participation in mandatory entry screening may be one option; though miners are required to receive X-rays at job entry and three years later, many do not.

On February 14, 2020, RHD published this notice of proposed rulemaking in the Federal Register. The autopsy portion was straightforward. amending the rules to allow for pathology payments that are keeping with modern prices, and the next steps for the B Reader decertification process.

At the conclusion of Dr. Laney’s presentation, questions were solicited from the Committee. Mr. Stewart asked if the change in the spirometry device required a barrier over the mouthpiece and, if so, would there be a systematic difference in values reported by the PFT as a result of that membrane? Dr. Laney responded that the membrane has been added and corresponding changes made to the software; with regard to the issue of how spirometry is used to look at the attribution of occupational exposure versus COVID, that will be important, especially when it comes to disability compensation. The Department of Labor will be faced with those issues, because especially in the

Federal Black Lung Compensation Program, completely disabling respiratory disease can be based on spirometry. A baseline in some form is required to understand what these long-term effects are; there have been some CT studies that have shown really devastating lung disease in coalminers that can cause fibrosis in the lung; that potentially could be used to say this is similar to what is seen with fibrotic lung disease occupationally.

Dr. Luxbacher then asked how many mobile units RHD currently has and if the upgrading was done to just one unit. Dr. Laney responded that RHD currently has two mobile units but only enough staff to have one out at any given time. RHD, in response to a request by the Congressional Budget Office, has provided estimates for another mobile unit that is more advanced and potentially adding low-dose CTs. The update during COVID was done to the one unit that is actually in use. Any new unit would have these features integrated. Dr Luxbacher then reminded the Committee from past presentations that the 2014 MSHA rules imposed an unfunded mandate on NIOSH and the Mining Program contributed funds on an ongoing basis ($1.5 million) to partially fund RHD for this work. As MSHA moves forward with a notice of proposed rulemaking related to silica standards, future impacts may occur to the RHD program.

Dr Schafrik asked about B Reader certification expiration; Dr. Laney explained that it must be renewed every five years. He reviewed the issues that had occurred with a B Reader associated with Johns Hopkins University several years ago, noting there needs to be a mechanism to be able to decertify B Readers when it is clear they are misusing their certification. Dr Schafrik then rephrased, for clarification, Dr. Laney's answer to an earlier question that research is required to determine if individuals who have had COVID or have had long-term symptoms from having COVID may or may not signal as being positive on a black lung exam. Dr. Laney responded that both are fibrotic lung disease, which can be seen on an X ray, or impaired pulmonary function, which would be picked up on spirometry. The long-term effects of COVID and severe COVID and synergistic effects that may be related to occupational exposures are unknown at this point but are important and will contribute to an understanding of attribution of impaired lung function. As mentioned previously, upon entry into the workforce miners now get both a spirometry test and X-ray and then it's mandatory to get an X-ray three years after starting employment to get a baseline. Unfortunately, historically, that had not happened. While for the last 50 years an X-ray was required before starting work, that only occurred less than half of the time, for a number of reasons.

Mr. Moore asked if the date the mobile unit is to be in West Virginia was determined so that it could be at the mine rescue event, as had occurred in the past. It is not; the plan is to go to active operations in southern West Virginia and eastern Kentucky.

Dr, Luxbacher noted that when NIOSH funded the National Academy study on respirable dust, NMA gave a presentation strongly endorsing mandatory X-rays for miners at regular intervals, supporting Dr, Laney's presentation relating to early detection. Dr. Laney, referring to a recent published paper on Part 90 participation, noted that miners often don't participate until they are 10, 15, 20 years into their work life, at which time they have more advanced disease, and nothing can be done about it; eighty-five percent of them know that they have black lung disease, and they know that they can move to a lower dust environment but choose not to. Mr. Moore asked if that decision was economically based; the response was, based on focus groups, RHD believes it is.

There is certainly a perception, whether true or not, that there could be retaliation, and some anecdotal evidence that there have been retaliatory efforts in the past, although there are legal recourses that can be pursued if that occurs. The miners who are most heavily exposed are at the face and these are the highest paid jobs; while their pay cannot be reduced if a miner moves to a different part of the mine under the Part 90 program, there may be production bonuses or overtime opportunities that they no longer qualify for.

Dr. Luxbacher then tied the discussion together with what being done intramurally within the Mining Program, focusing on dust control to reduce dust levels as prevention. The CPDM, while mandatory for regulatory compliance, is also effective in showing the worker the near real-time dust level so that they can take steps to minimize it. Unfortunately, it is an expensive device and consequently only those under regulatory requirements get the opportunity to wear one. very few people have the opportunity to wear it. During our National Academy study, miners addressing the panel stated that they would like to wear the CPDM more often, using it as a preventative measure. As a result, the Mining Program is funding a number of extramural contracts focused on a non-regulatory unit that is less expensive and less cumbersome to wear, such that it could be provided to every face worker, including the section foreman. CWP is a real issue, and the Mining Program hopes to give the mineworker empowerment, so that he can protect himself.

At this point the meeting entered the public comment period.

Public Comment Period

Chair Zimmer asked if any member of the public attending via Zoom wished to address the Committee. Bruce Watzman, retired from NMA, asked to speak. Mr. Watzman, who had served on the Committee twice previously, complimented the Chair and Committee on the format of this meeting. He then discussed the threat to the Mining Program and mining research through flat funding and unfunded mandates, the costs that the mining program is incurring that Congress does not provide any funding for. This also impacts the extramural program which augments the work that is done internally by NIOSH researchers, trains the academicians that are critical in the mining schools, and is a pipeline for highly qualified personnel for mining companies. The NIOSH Mining Program has always stepped forward with critical research to assist in a particular problem that the industry or mining companies were experiencing. He felt these functions were being threatened and will continue to do so as the program experiences a flat budget at a time of ever-increasing costs and called on the stakeholders to reach out to Congress to alleviate the situation. Dr. Luxbacher gave a brief summary of the extramural research program from its inception after the Miner Act was passed in 2006, funded by two emergency supplemental appropriations totaling $23 over two years, continuing with $10 million annually. That funding led to the communications and tracking systems in use today and enhanced the useability and viability of refuse alternatives. However, the Mining Program is now at the point where some of those funds are required to support our intramural efforts. The overall manpower level for the mining program has decreased significantly since 2006 to balance funding necessary to support the research activities. The Mining Program has also cut funding for the capacity build program supporting graduate

education; the two rounds of capacity build contracts, one on mine ventilation and one on ground control have been reduced to a single round now called mine design that incorporates ventilation and ground control. The overall program has produced a significant number of M.Sc. and Ph.D. graduates that went to work for the mining industry and NIOSH.

Dr. Kogel expressed her appreciation for Mr. Watzman' s comments highlighting a major concern that is expected to continue. To manage the flat funding, the Mining Program has turned to concepts such as matrix management to more fully utilize our human resources and leveraged the extramural program in support of the intramural program, operating within the constraints of the budget. The budget increases the Mining Program has received since FY 2020 have been directed toward university grants - none of that money comes to the NIOSH Mining Program but is rather a pass through. Dr. Luxbacher noted that the Mining Program looks at these grants as a collaborative opportunity to leverage both intra and extramural work.

Mr. Watzman asked if the chair of MSHRAC can, on behalf of the Committee, communicate to the appropriate members in the House and Senate of the respective appropriations committees and subcommittees the committee's concern relative to what is happening with funding for the Mining Program. Chair Zimmer responded that he would investigate the options and, if possible, pull members of the Committee and other stakeholders together for such an effort.

At this point Chair Zimmer invited Dr. Weeks, present in the room, to address the Committee; Dr. Weeks passed out a handout, included in the minutes as Appendix B. Dr. Weeks opened his remarks by stating he had worked for both the UMWA and MSHA before retirement and was speaking to the Committee as a private citizen. The 1969Coal Mine Act was a model attempt to prevent disease, including all of the basic public health approaches of primary, secondary, and tertiary prevention, primary prevention being the prevention of disease, secondary prevention of progression, and then compensation. Black lung starts as a long period of latency in which there are no symptoms. After miners are exposed, some disease occurs, but it's not really detectable, then progresses irreversibly. There is really no treatment for it, causing disability and early mortality. Primary prevention really is a very key element; the secondary prevention effort, reduced exposure after early indications of disease, serves only to prevent progression. The secondary prevention effort has had limited success for several reasons. One is the progression does seem to occur even without additional exposure, possibly due to silica. And the second is that the rate of miners' participation in the chest X-ray surveillance program has declined. Participation is often delayed until the end of their careers, possibly to document evidence for a black lung claim. Miners' participation is also impacted by a perception, real or not, related to employability.

From 1970 to 2000, there was a very steady and marked decrease in the prevalence of black lung; initially around 30 percent of miners with 10- or 12-years' experience had black lung, and then over the years it declined to a very low percentage. But starting around 2000, and continuing for the next 20 years, the prevalence of black lung has increased. Since black lung is caused by inhalation of respirable dust and silica, this begs the question, what happened to dust exposure levels that caused the increase in black lung? This is an issue that should be investigated in an organized fashion, like how MSHA investigates fatalities, to reform efforts and get back on track toward the original success of the 1969 Act.

Dr. Weeks described his investigation that looked at the occurrence of very low weight gain samples at around a tenth of a milligram, the lowest limit of detection for the analytical methods that used, rather than the high end of exposure; this has occurred more frequently in general amongst operator samples than amongst MSHA samples. Only Appalachian mines were examined, since that's where the prevalence of black lung is highest. He covered a 10-year period prior to 2000, since given the latency and the natural history of black lung, that's when the exposure happened

He calculated arithmetic averages, not geometric mean averages, for every mine in the Appalachian Region for that decade, and, as expected, it was a perfectly normal distribution. The tails were interesting, however. At the low end, he found about 50 or 60 mines in which the average exposure was a tenth of a milligram; the standard deviation was zero, which meant every sample was at a tenth of a milligram. These are operating mines taking samples under the regulatory routine. He finds valid exposure levels in producing mines that are coming up with a tenth of a milligram suspect, although he noted he had no proof. Similarly, at the high end, he also found about 50 mines where the 10-year average exposure was greater than two milligrams. This is not indicative of an episodic event, but rather exposure above two milligrams for 10 years has a higher probability of the occurrence of black lung.

He then looked at the distribution of the low weight gain samples to see if they were randomly distributed, and they were not. They occur in some mines and not in others, and they are not randomly distributed.

A third line of investigation was done by a graduate student of Dr. Weeks at George Washington University who matched MSHA with operator samples, matched as closely as possible to the mine, the section, and the date. For the most part, the difference between operator and MSHA samples centered around zero, with some distribution around and above it, but there were a group of mines in which the operator samples were significantly lower than the MSHA samples.

His conclusion is that black lung does not occur across the board, but rather occurs in some mines and not in others. There are some mines where the exposure is likely higher than it should be.

The then outlined several tentative reforms that he would like to see. He felt that the mine operator monitoring is suspect, and some significant reforms need to be made to assure credible samples, possibly by having MSHA take all of the samples for compliance. He also felt that use of the CPDM for compliance is a misuse of its true capabilities. It should instead be used as an adjunct to dust control, to take dust measurements at the time and the place where it occurs; if the dust measurements are matched with the operating conditions, controls can really be finely tune in a basic engineering approach.

At this point, the period for public comment expired and Dr. Weeks referred the Committee to his handout (included in Appendix B) for further comments. Chair Zimmer thanked Dr. Weeks, noting he appreciated his concerns and the outline of the issues. The Committee discussed further steps and Mr. Bowersox made a motion to form a subcommittee to follow up on Mr. Weeks' comments, volunteering to serve as Chair. The motion passed and Mr. Bowersox asked that the members contact him to participate.

Dr. Luxbacher reminded the Committee that NIOSH funded (for $1.8 million) the National Academy Consensus Study Report entitled "Monitoring and Sampling Approaches to Assess Underground Coal Mine Dust Exposures" that pulled together a lot of information and provided NIOSH, MSHA, and industry good recommendations; this report has served as a guiding document at NIOSH for both intramural and extramural work. The NAS looked at many of the issues that Dr. Weeks mentioned, although there is more work to be done, and NIOSH looks forward to seeing what recommendations come forward from the subcommittee. Dr. Weeks then noted he has a number of criticisms of the National Academy report.

Chair Zimmer then asked if there were any other public comments, either from in the room or online; there were none and the public comment period was closed.

Planning

The Committee then discussed the dates, location, and format for the next meeting. Potential dates will be circulated for input. Mr. Bowersox asked to start the meetings earlier. Dr. Luxbacher responded that since a hybrid meeting gets so much participation from both the Pittsburgh and Spokane Mining Program staff, the meeting has to start later when on the east coast. The opportunity to have virtually all of the researchers within the Mining Program listening to the presentations and advisory committee comments is invaluable.

Adjourn

At the conclusion of the meeting, a motion was made to adjourn, seconded, and unanimously approved. After lunch, the Committee was divided into groups for a tour and demonstrations of the PMRD laboratory facilities.

Appendix A – Attendees

Name		Affiliation	May 17	May 18
Moore	Todd	Consol Energy - Committee Membership Pending	X	X
Ellis	Mark	IMA-NA (retired)	X	X
Palmer	Wayne	IMA-NA	X	X
Zimmer	Kyle	IUOE - Committee Member (Chair)	X	X
Argirakis	Anthony	MSHA	X	X
Calhoun	Melanie	MSHA - Committee Member	X	X
Gardner	George	MSHA		X
Gray	Matthew	MSHA		X
Klobuka	Lawrence	MSHA	X	X
Moore	Joanna	MSHA	X	X
Shumaker	Wesley	MSHA	X	X
Stalnaker	Christina	MSHA	X	X
Stoltz	Jason	MSHA	X	X
Tomko	Deborah	MSHA	X	
Biscontin	Giovanna	NSF - Committee Member	X	X
Pritchard	Libby (Elizabeth)	NSSGA - Committee Member	X	X
Harman	Thomas	Portland Cement Association		X
Behringer	Kristina	Public - Committee Member	X	X
Mattson	Marifran	Purdue University - Committee Member	X	X
Stewart	Matthew	R. T. Vanderbilt - Committee Member	X	X
Brickey	Andrea	SDSM&T - Committee Member	X	X

Name		Affiliation	May 17	May 18
Schafrik	Steven	Univ. of Kentucky - Committee Member	X	X
Bowersox	Ron	UMWA - Committee Member	X	X
Duffy	Tom	USW - Committee Member	X	X
Benjamin	Pauline	NIOSH - OD	X	X
Howard	John	NIOSH - OD		X
Kogel	Jessica	NIOSH - OD Mining	X	X
Luxbacher	George	NIOSH - OD Mining, DFO	X	X
Metzger	Berni	NIOSH - OD Mining	X	X
Randolph	Bob	NIOSH - OD Mining	X	X
Reed	Randy	NIOSH - OD Mining	X	X
Steiner	Lisa	NIOSH - OD Mining	X	X
D'Alessandro	Maryann	NIOSH - NPPTL		X
Fernando	Rohan	NIOSH - NPPTL		X
Reynolds	Laura	NIOSH - RHD		X
Ajayi	Kayode	NIOSH - PMRD	X	X
Alcorn	Lynn	NIOSH - PMRD	X	X
Azman	Amanda	NIOSH - PMRD	X	X
Bahrami	Davood	NIOSH - PMRD	X	X
Barone	Teresa	NIOSH - PMRD	X	
Beck	Tim	NIOSH - PMRD	X	X
Bellanca	Jennica	NIOSH - PMRD	X	X
Bickson	Joseph	NIOSH - PMRD	X	X
Braunegg	Kathleen	NIOSH - PMRD	X	X
Brown	Connor	NIOSH - PMRD	X	X

Name		Affiliation	May 17	May 18
Carr	Jacob	NIOSH - PMRD	X	
Cecala	Andrew	NIOSH - PMRD	X	X
Chasko	Linda	NIOSH - PMRD	X	X
Chubb	Lauren	NIOSH - PMRD	X	
Cohen	Jessica	NIOSH - PMRD		X
Cole	Greg	NIOSH - PMRD	X	X
Compton	Craig	NIOSH - PMRD	X	X
Damiano	Nick	NIOSH - PMRD	X	
DeGennaro	Cory	NIOSH - PMRD	X	X
Dougherty	Heather	NIOSH - PMRD	X	X
Dubaniewicz	Tom	NIOSH - PMRD	X	X
Elmashae	Yousef	NIOSH - PMRD	X	
Evanek	Nicole	NIOSH - PMRD	X	X
Firestone	Jennifer	NIOSH - PMRD	X	X
Galanko	Joseph	NIOSH - PMRD	X	X
Gangrade	Vasu	NIOSH - PMRD	X	X
Geromi	Rebecca	NIOSH - PMRD	X	X
Girman	Matthew	NIOSH - PMRD	X	
Goodman	Gerrit	NIOSH - PMRD	X	X
Harris	Marcia	NIOSH - PMRD	X	
Hoebbel	Cassandra	NIOSH - PMRD	X	
Homer	John	NIOSH - PMRD	X	X
Hrica	Jon	NIOSH - PMRD	X	X
Hummer	Jon	NIOSH - PMRD	X	
Jiang	Hua	NIOSH - PMRD	X	X

Name		Affiliation	May 17	May 18
Jobes	Chris	NIOSH - PMRD	X	X
Johnson	Justin	NIOSH - PMRD	X	X
Keelyn	Matta	NIOSH - PMRD		X
Kimutis	Robert	NIOSH - PMRD	X	X
Klemetti	Ted	NIOSH - PMRD		X
Klima	Scott	NIOSH - PMRD	X	
Kocher	Lydia	NIOSH - PMRD	X	X
Kosmoski	Carin	NIOSH - PMRD	X	X
LaFollette	Angela	NIOSH - PMRD	X	X
Lambie	Brandin	NIOSH - PMRD	X	X
Lee	Taekhee	NIOSH - PMRD		X
Mallett	Launa	NIOSH - PMRD	X	X
Matta	Keelyn	NIOSH - PMRD	X	
Mayton	Alan	NIOSH - PMRD	X	
McLemore	Tamara	NIOSH - PMRD	X	X
Mechling	Jessie	NIOSH - PMRD	X	X
Mischler	Steven	NIOSH - PMRD	X	X
Mitchell	Kim	NIOSH - PMRD	X	X
Mohamed	Khaled	NIOSH - PMRD	X	
Nasarwanji	Mahiyar	NIOSH - PMRD	X	X
Navoyski	Jason	NIOSH - PMRD	X	
Njeri-Barkley	Ayanna	NIOSH - PMRD	X	
Orr	Timothy	NIOSH - PMRD	X	
Pascoe-Conteen	Andrea	NIOSH - PMRD	X	X

Name		Affiliation	May 17	May 18
Perera	Eranda	NIOSH - PMRD	X	X
Peterson	Shawn	NIOSH - PMRD	X	X
Potts	Drew	NIOSH - PMRD	X	X
Rashed	Gamal	NIOSH - PMRD	X	
Rayyan	Naseem	NIOSH - PMRD	X	X
Reyes	Miguel	NIOSH - PMRD	X	X
Ritter	Dylan	NIOSH - PMRD	X	
Robinson	Curtis	NIOSH - PMRD	X	X
Rowland	James	NIOSH - PMRD	X	X
Sammarco	John	NIOSH - PMRD	X	
Sawyer	Stephen	NIOSH - PMRD	X	X
Schatzel	Steve	NIOSH - PMRD	X	X
Schmidl	Angela	NIOSH - PMRD	X	X
Slaker	Brent	NIOSH - PMRD	X	X
Srednicki	Justin	NIOSH - PMRD		X
Tang	Wei	NIOSH - PMRD	X	X
Trackemas	Jack	NIOSH - PMRD	X	X
Vanderslice	Shawn	NIOSH - PMRD	X	
Wacaster	Sue	NIOSH - PMRD	X	X
Walker	Rachel	NIOSH - PMRD	X	X
Willmer	Dana	NIOSH - PMRD	X	X
Wolf	Candace	NIOSH - PMRD	X	X
Wolfe	Cody	NIOSH - PMRD	X	
Xue	Yuting	NIOSH - PMRD	X	X
Yan	Lincan	NIOSH - PMRD	X	

Name		Affiliation	May 17	May 18
Yantek	Dave	NIOSH - PMRD	X	X
Yekich	Milan	NIOSH - PMRD		X
Yuan	Liming	NIOSH - PMRD	X	X
Zhang	Alan	NIOSH - PMRD	X	X
Zheng	David	NIOSH - PMRD	X	
Zhou	Jim	NIOSH - PMRD	X	X
Bissonette	Bob	NIOSH - SMRD	X	X
Eiter	Brianna	NIOSH - SMRD	X	
Emery	Tyler	NIOSH - SMRD	X	X
Halldin	Cara	NIOSH - SMRD	X	X
Hyun	Bo	NIOSH - SMRD	X	X
Jacksha	Ron	NIOSH - SMRD	X	X
Johns	Doug	NIOSH - SMRD	X	X
Larson	Mark	NIOSH - SMRD	X	
Lawson	Heather	NIOSH - SMRD	X	X
Mancillas	Danielle	NIOSH - SMRD	X	
McNinch	Michael	NIOSH - SMRD	X	
Misra	Shilpi	NIOSH - SMRD	X	X
Nixon	Carol	NIOSH - SMRD	X	X
Raj	Vaibhav	NIOSH - SMRD	X	
Ruff	Todd	NIOSH - SMRD	X	X
Sbai	Samir	NIOSH - SMRD	X	
Seymour	Brad	NIOSH - SMRD	X	
Sussell	Aaron	NIOSH - SMRD	X	
Terzi	Danis	NIOSH - SMRD	X	X

Name		Affiliation	May 17	May 18
Vrincean	Ion	NIOSH - SMRD	X	X
Wilson	Samantha	NIOSH - SMRD	X	
Darby	Ken	Public		X
Dewey	Daniel	Public	X	
Louk	Kyle	Public	X	
Michalek	Stan	Public		X
Peelish	Michael	Public	X	X
Retzer	Patrick	Public	X	X
Skorski	Dean	Public	X	X
Skrabak	Rick	Public		X
Snyder	Michael	Public		X
Watzman	Bruce	Public	X	X
Weeks	Jim	Public	X	X
Wellman	Dakota	Public	X	
Wharry	Matthew	Public		X
Wright	Mike	Public	X	X

TOTAL: 160

Appendix B - Materials Submitted by Members of the Public

MSHRAC. Pittsburgh, May 18, 2022

James L. Weeks, ScD

Handout

Findings, Suggested Reforms for Preventing Pneumoconiosis

1. The occurrence of pneumoconiosis (both CWP [PMF] and silicosis) since 2000 is not expected, given the success in prevention efforts from 1970 to 2000. Need to find out why it occurred and what needs to be done to reverse the trend. (Assume knowledge of increase prevalence; want to focus on dust (including silica) exposure and control.)

2. The cause of this resurgence is exposure to elevated levels of respirable dust and silica from 1990 to present from a failure of the dust control plan in the Coal Mine Act of 1969.

3. There is need to investigate what happened and to make reforms. (MSHA investigates fatalities and catastrophes, providing ample precedent.)

    a. Dust Monitoring, Enforcement, Control
    b. Chest x-ray surveillance, Part 90

4. Indicators of problems in dust control.

    a. Low concentration (0.1 to 0.3 mg/m^3) samples more frequent in operator v. MSHA samples (Boden, AmJIM 1984 6(6), 427

    b. Significant differences in MSHA v. matched operator samples in some mines. (Ranpuria, Masters' Thesis, GWU, 1995

    c. Higher than expected occurrence of low concentration (=0.1 mg/m^3) samples in operator samples. Ratio of Observed / Expected by chance (=20) based on mines in Appalachian region (Weeks, AmJIH, 1990, 56(4),)28

    d. Operator samples (Appalachian mines, 1990's) distributed by exponential decay, not log-normal, suggesting over-representation of low concentration samples (Appalachian mines, 1990's). (Weeks, draft)

    e. At Upper Big Branch mine, results of dust sampling are inconsistent with occurrence of pneumoconiosis based on autopsies (one mine, small sample; MSHA investigation of mine explosion) MSHA, Report, Upper Big Branch, 2010.

f. History of corruption in operator samples. Weeks AmJPH, 2003, 93(8), u36; Weeks AmJIM, 1991, 20(2), 141

g. Anecdotal evidence of improper sampling methods since 1970, most recent, 2018 (Reynolds, JOEH 2018, 60(11) 575, Howard [Director of NIOSH], Statement to House Cmte Ed & Labor, 2019; Reports from UMWA miners).

h. Mine-specific averages: (Appalachian mines, decade of 1990, Weeks, draft
   i. number of mines with *all* samples =0.1 mg/ml
   ii. number with average 2.0 mg/m^3,
   iii. small number of samples (< 10) per mine.

5. Chest x-ray Surveillance

   a. Decline in miner participation in Chest x-ray surveillance

   b. Cases of CWP, PMF among miners who had not participated in CXRSP

   c. Decline in participation in Part 90

   d. Findings that progression occurs in absence of continued exposure, probably associated with exposure to silica

6. Investigation needs

   a. Were proper sampling methods used? Samples required to be taken during "normal" production. Compare sampling frequency with production. But sampling for silica needs to be task-specific.) (C Roberts statement to House Cmte Ed & Labor, 2019; Reports from UMWA miners).

   b. Why are there so few samples at some mines?

   c. Effects of silica exposure: more fibrogenic, dose rate dependent (acute silicosis), freshly fractured silica is more toxic. (C Roberts, UMWA Pres)

   d. Identify miners with CWP (PMF), if possible, interview them concerning conditions resulting in over-exposure and reconstruct their exposure and work history by identifying the mines where they worked. Do the same with state workers• compensation cases. (Identifying mines is not for the purpose of issuing retroactive citations for non-compliance.) (It is conventional standard practice of physicians to reconstruct patient's exposure in order to evaluate occurrence of disease and determine its cause.)

      i. To find out how and why over-exposure occurred in order to improve exposure control.

ii. Returning to mine associated with cases facilitates case-finding of additional cases (cost-effective method, Rosenman, AmJIM., 2009, 36(6), 628

7. Possible reforms. (Opportunities created by CPDM, developed in 1980's; the CPDM is analogous to methane detector.)

   a. "Miner's Choice" program. (Allow miner to choose facility, date, time for chest x-ray, results go to the miner, apply HIPPA, miner decides what to do if a (+) film.)

   b. Operators should evaluate exposure using CPDM as an engineering tool in order to identify specific working conditions and work practices and develop more efficient controls.

   c. Operators should not take samples to determine non-compliance (a conflict of interest).

   d. MSHA should determine non-compliance. (Recommended by Seel.ab Advisory Committee on Elimination of CWP, 1996)

   e. Need sampling protocol specifically for silica; task-specific, not linked to production. (Need a permit for cutting into silica laden rock?) (Cecil Roberts, Pres UMWA)

   f. Determine conditions resulting in excess exposure to silica, improve monitoring for silica, not using "reduced standard," (Jo CFR 70.101)

   g. Reduce PEL for silica (already underway?) (NIOSH REL published in 1972, updated in 1981)

   h. PEL for respirable dust and for silica should be a TWA. (ACGIH, 1939; Casarett & Doull, Toxicology; AIHA)

   1. Focus on dust control and eliminate fine-tuning of sampling, e.g., so-called OSP, S&S citations for single violations, eliminate use of error factor for compliance purposes, do not reduce samples by rock dust. (RCMD is basis for PEL, it is a mixed dust, includes rock dust.)

   j. Apply POV rule for violations of PEL for RCMD and silica. (e.g., POV status if 6 mo. or 1 year average $\geq$ PEL, based on MSHA samples, or on failure to monitor exposure.) (30 CFR Part 104)

I hereby certify that, to the best of my knowledge, the minutes of the May 17 & 18, 2022 meeting of The Mine Safety and Health Research Advisory Committee (MSHRAC) are accurate and complete.

_____ Date

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Chair, Mine Safety and Health Research Advisory Committee