Alpha Foundation for the Improvement of Mine Safety and Health, Inc.

First Solicitation, 2013

Synopses of Funded Projects

Starting Date: November 1, 2013

Project Title: Numerical Modeling Methodologies for Assessing Burst Potential in Coal Mines

Organization: Colorado School of Mines

Partnerships: N/A

Investigator(s): Ugur Ozbay

Focus Area: Safety

SYNOPSIS

Problem Statement and Justification: Rock around underground mining excavations may fail in a gradual or sudden manner as stresses are increased due to progressive mining. Unstable failures are observed in both coal and hard rock mines and are commonly referred to as coal bumps and rockbursts, respectively. Large unstable failures come in the form of massive collapses or cascading pillar failures. Slips along large discontinuity planes may also take place. More localized forms of unstable failures may affect smaller areas of a mine or even isolated sections of a single pillar or sidewall. This proposal addresses such violent unstable failures in terms of assessing their potential for occurrence and their expected intensity in deep coal mines. The threat of dangerous coal bump events increases with depth and with higher levels of extraction. Additional factors, which are conducive to coal bumps, include strong roof and floor conditions, multiple seam mining, or existing faults and discontinuities in the surrounding rockmass. Numerical models provide additional tools with which to explore the underlying mechanistic causes of these failures as they relate to deep coal mines across the U.S. As part of this project, a series of coal bump case histories will be selected across a range of coal mining environments which will include violent compressional failure of support rock and unstable slip along large discontinuities. The bump hazard will be assessed through the total excess energy and local excess energy densities. The development of these methods is expected to support bump mitigation methods currently in use in deep coal mines to ultimately reduce the risk of injury to miners.

Impact of the Research: The successful completion of this research would lead to a consistent methodology for assessing the threat of coal bumps through calculations of available excess energy using explicit numerical models. The measure of excess energy may then be applied with greater confidence to future studies of coal mines and deep mineral mining operations as a coal bump and rockburst mitigation method. Insight will additionally be gained on the mechanistic factors which contributed to each selected coal bump case history. A numerical methodology for assessing coal bumps and the knowledge gainedon each historical bump case may ultimately be applied to reduce the risk of injury to mine workers posed by dangerous coal bump events. The project will also produce qualified rock engineering personnel who can take positions at universities or in the mining industry which focus on mine safety.

Objective and Research Approach: The objective of the project is to develop numerical modeling methodologies for assessing bump potential of a given coal mine setting. This objective will be achieved through backanalyses of previous coal bump events using numerical modeling methodologies, which we have recently developed as part of our research on improving the understanding of unstable failure mechanisms. Several historical cases of coal bump events that occurred in retreat, longwall, and room-and-pillar mines will be backanalysed using FLAC and UDEC codes in two- and three-dimensional models. Unstable compressive failures in the coal seam and slip along a pre-existing discontinuity will be explored. The research approach involves four specific tasks: i) establish and prepare about six to ten case studies that will be used for the backanalysis studies; ii) further develop the unstable failure modeling approach for mine-scale models; iii) develop numerical modeling methodologies for assessing excess energy availability in mine-scale models; and iv) develop modeling-based bump assessment procedures by testing and further developing the outcome of these tasks through backanalysis studies.

Project Title: Development of a New Rock Dust Sampling Instrument

Organization: Colorado School of Mines

Partnerships: None

Investigator(s): Jürgen F. Brune
Gregory Bogin
Masami Nakagawa

Focus Area: Safety

SYNOPSIS

Problem Statement and Justification: A violent coal dust explosion at the Upper Big Branch mine on April 5, 2010 killed 29 miners and injured two. Accident investigators found that the coal dust in the mine had been inadequately inertized with rock dust and caused an explosion that propagated through miles of underground mine workings. To improve the mine operator's ability to evaluate whether mine dust is explosive, project researchers will design, build and test a pneumatic, handheld device to sample mine dust in underground coal mines, the Dust Sampling Device (DSD). The pneumatic action in the DSD mimics the dust entrainment process that happens during a coal dust explosion. Current dust sampling is carried out with a pan and brush, which may lead to inaccurate, non-representative and non-repeatable samples.

Impact of the Research: Researchers believe that an objective sampling method is necessary to help identify areas in mines where the level of inertization is insufficient and where additional rock dust must be applied. Every mine operator needs to effectively control the coal dust explosion hazard, which requires objective and accurate mine dust sampling. Researchers believe that pneumatic sampling is more accurate and objective than conventional sampling. The DSD will be used in conjunction with the NIOSD-developed Coal Dust Explosibility Meter (CDEM) and provide a near- instantaneous assessment of the coal dust explosibility hazard. Researchers expect that the DSD will become commercially available within five years.

Objective(s) and Research Approach: Researchers will use Computational Fluid Dynamics (CFD) modeling to design a handheld, pneumatic mine dust sampling unit, the DSD. The goal is to sample only the portion of the mine dust that would be entrained by an explosion and would propagate it. Mine dust that cannot be entrained because it is wet or buried too deeply will not participate in a dust explosion and therefore, should not be included in a sample. Researchers will build the DSD from commercially available components.

Researchers will first verify and document the DSD function and sampling process in the laboratory. Pneumatic sampling will be compared to conventional, pan-and-brush sampling. Next, the DSD will be tested in an actual mine setting in the Colorado School of Mines Edgar Experimental Mine, where realistic mine dust conditions can be created in a controlled environment with consistent mine ventilation. Side-by-side comparisons with conventional mine dust sampling will be carried out and documented. Finally, researchers will test, demonstrate and verify the DSD function and accuracy in several underground coal mines, again comparing results to conventional samples taken with a pan and brush.

Project Title: The Application of Flooded Bed Dust Scrubbers to Longwall Mining Systems

Organization: University of Kentucky

Partnerships: Alliance Coal, LLC
Joy Global
NIOSH Office of Mine Safety and Health Research

Investigators: Thomas Novak (PI),
Joseph Sottile (Co-PI)
William C. Wedding (Co-PI)

Focus Area: Safety and Health

SYNOPIS

***Problem Statement and Justification*:** Dust is a detrimental, but inherent, consequence of any mining process and is particularly problematic in underground coal mining. Coal workers' pneumoconiosis is a debilitating and irreversible lung disease resulting from long-term overexposure to respirable coal dust. Although its prevalence has steadily and significantly declined since the Federal Coal Mine Health and Safety Act of 1969, NIOSH indicates that health hazards associated with *respirable dust* still exist. Coal dust can also create a potentially catastrophic safety hazard. Airborne dust, if not removed near its source, is transported and dispersed downstream throughout a mine by the ventilation airstream. This dust, known as *float dust*, is subsequently deposited on all surfaces as it permeates through mine airways. A potential safety hazard occurs if an insufficient amount of rock dust is applied to mine surfaces, and the settled coal dust is not adequately diluted to an inert mixture. If a methane ignition occurs, its resulting shockwave propels the settled dust into the airstream, creating an explosive dust cloud. The initial methane ignition can then transition to a dust explosion that propagates throughout mine airways until its fuel (explosive dust) is exhausted.

Impact of the Research: The ultimate goal of the proposed project is to design and fabricate a functional prototype scrubber system with high capture and cleaning efficiencies that can be incorporated into a longwall mining system. Therefore, capturing and removing coal dust at its source will mitigate the probability of two major dust hazards that continue to plague the mining industry.

Objectives and Research Approach: Longwall mines, which account for approximately one-half of the coal produced by underground mines in the U.S., exhibit greater difficulty in maintaining compliance with federally mandated dust regulations, compared with continuous mining operations. Therefore, the project effort is directed toward application of a flooded-bed dust scrubber to a typical U.S. longwall system. Futhermore, the research will only focus on the application of a scrubber to the headgate side of the shearer, thus increasing the probability of success for this initial effort. Air-quantity and dust measurements made at various locations along the longwall face will be utilized to construct computational fluid dynamics models to depict airflow patterns that occur along the longwall face and shearer. A scaled physical model will be constructed to verify the accuracy of CFD models. These models will then be used to determine the capacity requirement of the scrubber, as well as the optimum locations for the inlet and discharge of the scrubber. The placement of deflection curtains, created by water sprays and/or physical material, will be analyzed for helping direct the dust cloud toward the scrubber inlet and minimize dilution by the ventilation airflow. Conceptual designs will be developed and the capture and cleaning efficiencies for these prototypes will be tested at the NIOSH's longwall dust gallery in Pittsburgh, Pennsylvania. If the test results are positive, discussions will be held with the mining-machine manufacturer to investigate further refinement, development, and incorporation of the system into their shearer design.

Project Title: Control of Spontaneous Combustion Using Pressure Balancing Techniques

Organization: University of Utah Mining Engineering Department

Partnerships: (None)

Investigators: Felipe Calizaya
Michael G. Nelson

Focus Area: Safety

SYNOPSIS

Problem Statement and Justification: In the U.S., by law, worked out areas in coal mines must be either ventilated by a bleeder system or isolated by explosion-proof seals to exclude leakage flow. Experience has shown that seals are not airtight structures as such they allow some leakage of air into the gob. In fact, seals "breathe in and breathe out" with changes in barometric pressure. In some mines the gob is kept under negative pressure. Under these circumstances, an increase in barometric pressure may cause an influx of fresh air into the gob. This quantity may be sufficient to start the self-heating of coal and spontaneous combustion, with the possibility of a catastrophic underground fire.

Pressure differentials in the gob atmosphere can be controlled in several ways. One of the most straightforward is to use a positive pressure balancing system. By maintaining the gob at a pressure slightly higher than the barometric pressure, the ingress of oxygen to the gob can be reduced or eliminated, greatly reducing the risk of fires from spontaneous combustion.

Impact of the Research: Spontaneous combustion (sponcom) is a safety hazard frequently found in underground coal mines. If not detected in time, it can lead to mine fires and explosions. Low- rank coals, like those found in the western U.S., can self-heat and combust at temperatures as low as 95ºF. Sponcom fires account for approximately 15% of the total number of fires recorded in the U.S. since 1990, and have claimed the lives of many miners. Two such events have occurred as recently as 2003, one in the U.S. and one in Australia. Pressure balancing is one proven way to control self-heating and the consequent fires in coal mines. An exhaustive laboratory analysis of pressure balancing techniques will lead to a thorough understanding of the method, so that technical guidelines for its implementation can be issued to the industry.

Objectives and Research Approach: The research will be accomplished in the following steps. First, ventilation surveys in two operating mines will be conducted at U.S. mines, one in the east and one in the west. These surveys will provide baseline data for laboratory work. Second, a lab model of a mine gob will be constructed. Third, the model will be fitted with an automatic pressure balancing system. Fourth, tests and experiments will be conducted with the model, and parameters for optimization of the pressure balance in the model will be determined. Finally, guidelines for the design and implementation of pressure balancing systems in operating mines will be prepared, reviewed, and disseminated to the professional and industrial communities. It is anticipated that this work will provide a basis for future research related to spontaneous combustion, mine fire detection, and mine fire control.

Project Title: Operational Sensitivity of Through-The-Earth Communication

Organization: Virginia Polytechnic Institute and State University (Virginia Tech)

Partnerships: Virginia Center for Coal and Energy Research (Lead)
Lhoist North America
James River Coal Company
Prairie State Generating Company
Carroll Technologies
Lockheed-Martin

Investigator(s): Steven Schafrik, PI
Chester Weiss, Co-PI
Ellen Gilliland, Co-PI

Focus Area: Safety

SYNOPSIS

Problem Statement and Justification: Through-the-Earth (TTE) communication systems will play an important role for maximizing worker safety and facilitating rescue operations in emergency situations. However, at this time TTE is a burgeoning technology with only one system commercially available and one not yet commercially available. How to effectively deploy TTE technologies in the complex geologic setting of an active underground mine, and more importantly, under the logistical constraints imposed during a mining emergency, has not yet been examined. Limited worker mobility during a mine collapse, restricted topside access, and the presence of mining infrastructure each affect the effectiveness of TTE communications, as does the inherent geologic complexities of the subsurface through which the TTE signal must propagate.

Impact of the Research: This research will answer the critical question, "What is the effect of these complicating factors and how must the TTE operational team deal with these effects in order to save lives?" Those deploying the communication unit above ground will have a better understanding and methodology for deployment when guided by the experience developed during this project. Implementation of the guidelines and tools developed will ensure that the operational envelope of the communications system is well defined, allowing the system to be optimally deployed during an emergency, to support successful rescue operations.

Objective(s) and Research Approach: The objective of this project is to develop guidelines for using TTE technology, taking an experimental approach assisted by theoretical work. This project addresses the problem of quantifying the effect of geologic and logistical complexity on TTE communications. The specific aims of the project are 1) to identify performance factors; 2) test and evaluate performance related to those factors; and 3) develop operational and planning recommendations for effective deployment of TTE communications systems. This will be accomplished through a hybrid approach of field testing supported by state of the art TTE simulations for 3D geologies.

Project Title: Integrated Surface Mining Safety System.

Organization: West Virginia University Foundation.

Partnerships: Red Hills Mine, Mississippi Lignite Mining Company (North American Coal)

Investigator(s): Vladislav Kecojevic (PI)
Vinod Kulathumani (Co-PI)
Bojan Cukic (Co-PI)
Ashish Nimbarte (Co-PI)

Focus Area: Safety

SYNOPSIS

Problem Statement and Justification: Although the total number of mining fatalities have trended downward during the past two decades, the proportion of these fatalities involving mining equipment (powered haulage, machinery and hoisting) has consistently been significant. According to the MSHA records, a total of 643 fatalities, or 68.8%, is attributed to the mining equipment from 1995 to 2011. Further analysis of MSHA data indicates that 85.1% of truck-related fatalities, 80% of conveyor related fatalities, 84.6% of loader-related fatalities, and 87.1% of dozer-related fatalities occurred in surface mining. In order to reduce these fatalities, the mining industry has applied numerous technological and engineering advances, behavioral principles, and training programs. Yet, challenges still remain as evidenced by the persistent recunence of fatalities and the significant proportion of equipment-related fatalities as compared to all fatalities that occur in US coal, metal and non-metal mining. Additional problem represents a lack of research capacity in surface mining safety in US mining schools.

Impact of the Research: The outcome of the project has a potential to address the root causes of equipment- related fatal and non-fatal injuries in the surface mining operations. The proposed system is expected to provide both real time processing and hazard identification, and also support post processing of the data for the analysis of patterns that may be significant for hazard mitigation. As opposed to leaving individual sensing sub-systems disconnected, all components will be integrated into a common information management. Such an integrated system will enable the data from multiple sensing sub-systems to be fused and hence facilitate more exhaustive hazard monitoring, tisk analysis and Jong-tenn data analytics for risk management.

Objective(s) and Research Approach: The main objective of this research is to develop and deploy an integrated safety system to help reduce equipment-related fatal and non-fatal injuries. We will (i) design a large-scale sensor network system; (ii) establish infrastructure communication platform and information management system for real-time situational awareness; (iii) provide a non-distractive User Interface for equipment operators/drivers and an integrated, informative console for mine operation management; and (iv) educate and train a new generation of professionals who will be working on surface mining safety research. The proposed system will include features such as existing proximity warning system and non-invasive eye detection and tracking system for drivers fatigue; vehicular motion profile; illumination on the site; critical intersections in the mine; reduced visibility due to factors such as dust and fog; speed of the vehicle; and warning signals if maintenance of the equipment is not conducted after certain miles and/or hours. The proposed integrated system will be tested and deployed at an operating surface coal mine in southern US.

Project Title: Whole Body Vibration Exposure and Injury Prevention of Heavy Equipment Operators in Open Pit Coal Mines.

Organization: Northeastern University

Partnerships: University of Washington, Seattle
Javeriana University
Cerrejón (Mine Industry Partner)

Investigator(s): Jack T Dennerlein
Peter Johnson
Lope Barrero

Focus Area: Health

SYNOPSIS

Problem Statement and Justification: Miners who operate heavy equipment vehicles (HEV) in open pit mines have a high prevalence of musculoskeletal disorders (MSDs). While sedentary for most of the day these miners are also exposed to whole body vibration, especially shock impulse vibration due to the operation of HEVs including. For example, the operation of HEVs such as hydraulic shovels and load haul trucks during aggregate transfer during the extraction process in mining operations exposes workers to shock impulse vibrations. Whole- body vibration (WBV) is one of the leading risk factors for the development of low back musculoskeletal disorders and other general health outcomes among professional vehicle operators. Epidemiological and physiological studies demonstrate consistent associations between exposure to WBV from professional driving and occupational back pain and disability with the risk of injury increasing as WBV duration and dose increase.

Impact of the Research: Due to the high rate of injuries and MSDs in the mining industry, this research will have direct impact on miners' health by addressing a common exposure, WBV and its effect on their health. Our specific goals are to:

(1) Characterize workers' peak and impulsive shock WBV exposure utilizing improved WBV exposure metrics that better capture these shock WBV during the operation of study HEVs.
(2) Test associations between these improved WBV exposure metrics and MSD related absenteeism recorded in our partner's employee occupational health records, HEV operating logs.
(3) Identify potential engineering controls and seat suspension technology to reduce the exposure to these peak and impulsive shock WBV.

The specific impact of these goals will be to (1) identify sources of exposure to WBV using innovative exposure metrics, (2) identify of exposure and health outcome relationships, mainly absenteeism due to MSDs, and (3) identify engineering controls that can be implemented as a primary prevention effort.

Objective(s) and Research Approach: The broad objective for this research is to characterize whole body vibration exposures in order to develop feasible and effective approaches for reducing exposure to whole body vibration among heavy equipment vehicle operators in mines. Our approach has multiple complementary facets that combine several health and safety methods, specifically, completed detailed exposure assessment and exposure assessment modeling for all workers, the utilization of administrative data to examine the health and safety of an employee cohort, and surveillance of workers to examine work environment and individual factors and their associations with the health outcomes. In achieving the goals will develop a better understanding of interactions between the physical exposure and both work environment and individual factors in order to improve miners overall health and safety.

Project Title: Ischemic Heart Disease and Lung Cancer Mortality in Relation to Respirable Particulate Matter and Diesel Exhaust in Non-metal Miners

Organization: University of California, Berkeley

Partnerships: None

Investigator(s): Ellen A. Eisen

Focus Area: Health

SYNOPSIS

Problem Statement: This research will estimate the exposure-response relationships between respirable particulate matter (RPM) and elemental carbon (REC) and ischemic heart disease (IHD) and lung cancer mortality in a cohort of miners without bias from the healthy worker effect. Miners are exposed to levels of RPM that far exceed general population exposures in air pollution. Yet although RPM in traffic-related air pollution is recognized as an important risk factor for heart disease and IHD has rarely been studied in relation to dust exposure among miners. Moreover, most of the few existing studies on this topic compare miners to the general population; such comparisons can lead to misleading results because miners are an unusually healthy and physically fit workforce. The Diesel Exhaust in Miners Study (DEMS), originally designed to study lung cancer, offers the unique opportunity to examine IHD mortality in relation to respirable PM and EC exposure without healthy worker bias by relying on internal comparisons between higher and lower exposed miners.

Impact of Research: The goal of the project is to provide exposure-response curves for ischemic heart disease and lung cancer mortality that can be used to guide MSHA regulations for RPM and REC in coal and other non-metal mines.

Objectives and Research Methods: Our objective is to estimate quantitative exposure-response curves between each of two exposures, RPM and REC, and two mortality outcomes, IHD and lung cancer. The particular challenge is to estimate these relationships without bias due to the healthy worker survivor effect or confounding by cigarette smoke. Using the analytical approach described below, this project will provide answers to the following questions:

1. What is the unbiased quantitative relationship between exposure to respirable particulate matter (RPM) and IHD mortality? Lung cancer mortality?

2. What is the unbiased quantitative relationship between exposure to respirable elemental carbon (REC) and IHD mortality? Lung cancer mortality?

We will answer these questions by applying Cox models with penalized splines to allow non-linearity, and focus on time windows of exposure, with a particular interest in the impact of recent exposure among the actively employed. We will then apply g-methods to correct for the downward bias due to the healthy worker survivor effect, adjusting selection bias from both left and right truncation by incorporating censoring weights into the Cox models. We will adjust for smoking and BMI by leveraging smoking data collected for a case-control study of lung cancer nested in the cohort and conduct sensitivity analysis for both primary exposure-response analyses with and without adjustment for cigarette smoking.

Project Title: Clarifying Distribution, Trends, and Determinants of Adverse Health in United States Miners: Exploration and Integration of Existing Data Systems

Organization: University of Illinois at Chicago

Partnerships: West Virginia University School of Medicine
National Jewish Health, Division of Environmental and Occupational Health
Rutgers Robert Wood Johnson Medical School
Environmental and Occupational Health Sciences Institute

Investigator(s): Robert Cohen, University of Illinois at Chicago
Judith Graber, Rutgers Robert Wood Johnson Medical School
Edward Lee Petsonk, West Virginia University
Cecile Rose, University of Colorado
Leslie Stayner, University of Illinois at Chicago

Focus Area: Health

SYNOPSIS

Problem Statement and Justification: Miners in the United States continue to suffer from an excess of chronic respiratory disease as well as other adverse health effects resulting from their occupational exposures. Although acute injuries and fatalities from mining safety failures are easily recognizable, disease and death from mining-related chronic health disorders are more difficult to identify and affect a much larger portion of the mining population, and cause substantial impairment, disability, and mortality. Surveillance and research programs are urgently needed to elucidate the impact of the broader spectrum of respiratory disease, including pneumoconiosis and chronic obstructive pulmonary disease, and to provide information on the determinants of cardiovascular disease among all U.S. miners.

Impact of the Research: This research will provide an accurate description of how existing data systems can be used and enhanced to develop interventions to improve miners' health. The results of this work will be disseminated to stakeholders to develop short and long term recommendations to improve miner health through enhanced disease detection, prevention and health promotion. Recommendations will be made to improve the public health utility of data from clinics that provide primary and specialized care to miners. We will provide information to the mining industry and mining community health programs regarding the prevalence of CVD and obstructive lung diseases that can guide interventions to prevent those disorders. Finally, these efforts will lay the groundwork for on-going targeted research into the health risks faced by miners and how these risks can be optimally addressed and controlled.

Objectives and Research Approach: Epidemiologic methods will be used to analyze datasets from multiple agencies and organizations and integrate these data to document determinants of miners' risk for respiratory and cardiovascular disease. The data sets include: National Institute for Occupational Safety and Health, Division of Coal Mine Workers Compensation and Mine Safety and Health Administration of the United States Department of Labor, United Mine Workers of America Health and Retirement Funds, National Coalition of Black Lung Clinics, and Worker's Compensation Data from the States of Illinois, Colorado, and West Virginia. The datasets will be linked to provide enhanced information for enumerating disease prevalence and risk factors. Pilot analyses will be conducted using the most promising data sources and data linkages to further understand how these data can be used to plan and evaluate specific interventions. The approaches taken to disseminate the results will focus on providing a scientific foundation for specific actions that can directly improve disease prevention and health promotion in miners as well as recommendations that will improve future collection of miner health data.

Project Title: Connecting Dust Characteristics and Worker Health in Underground Mining

Organization: University of Pittsburgh

Partnerships: Virginia Tech
Alpha Natural Resources, Inc.

Investigator(s): Jeanine M. Buchanich (UPitt)
Emily A. Sarver (VT)

Focus Area: Health

SYNOPSIS

Problem Statement and Justification: Recent observations have found increased incidence of coal workers' pneumoconiosis (CWP) or other lung disease, particularly amongst young miners in the eastern US, raising questions over both the cause(s) for these concerning trends and potential strategies for combating them. Presently, the regulatory community is moving toward a reduced limit on permissible exposures to respirable coal dust concentrations, but many argue this approach may be ineffective because excessive dust *concentrations* are perhaps not the primary root of the problem. In fact, little is known about the influence of specific dust *characteristics* and associated exposure patterns on lung disease in underground coal miners. Few studies have examined these potential causal factors in detail, and none have collected the comprehensive data required to make connections between specific dust exposures and health outcomes. The specific objective of the project is to perform a comprehensive study considering characteristics of occupational coal mine dust exposures and associating these data with individual worker lung function. Multiple underground coal mines in both Central Appalachia (CA) and Northern Appalachia (NA) will be used as study sites to provide access to a range of mining-specific factors of interest and a large cohort of miners.

Impact of the Research: After 30 years of decline, the recent and unexplained rise in debilitating lung disease in young coal miners represents an urgent concern – and a renewed need for vigilance in both identifying and preventing the responsible exposures. Because obstructive lung disease often occurs in miners without detectable abnormalities on routine chest x-rays, recent recommendations by NIOSH include regular lung function tests to detect rapid functional decline and permit timely interventions and preservation of lung health. This project will associate lung function among coal miners with exposure to specific dust characteristics. The Central Appalachian mines will provide the opportunity to study relatively small, "low-seam" operations in the region where CWP appears to be on the rise. The inclusion of Northern Appalachian mines will allow a contrast in mining practices, occupational and employment differences, and rock and dust characteristics (i.e., longwall, larger mines, thicker seams, and lower observed incidence of CWP). The project will address a critical gap in the understanding of dust exposure related to coal mining and worker lung function and disease.

Objective and Research Approach: To meet the stated objective, UPitt and VT researchers will perform a three-year project of intensive field study to gather and analyze critical data. The two major aims are: 1) comparison of respirable dust exposure characteristics by primary occupation and mine environmental conditions (VT); and 2) associations of worker lung function, personal risk factors, and occupational history, with primary occupation and mine environmental conditions (UPitt). Data will be collected on dust characteristics related to coal mining seam heights and mining conditions, job classes, and lung function tests among groups of coal miners in various types of mines and jobs from Alpha mines in the Central Appalachian and Northern Appalachian regions, with control for potential confounding factors, such as smoking and occupational history.

Project Title: Characteristics of, and Barriers to Effective Hazard Identification and Current Control Programs in U.S. Metal and Non-Metal Mines

Organization: The Steelworkers Charitable and Educational Organization

Partnership: Department of Occupational and Environmental Health Sciences
West Virginia University School of Public Health (Dr. Douglas Myers)

Investigator(s): Michael J. Wright

Focus Area: Safety and Health Management

SYNOPSIS

Problem Statement: Regulatory agencies in the United States manage worker safety and health with rulebooks – extensive lists of hazard-specific OSHA and MSHA standards. But the standards will never cover every hazard, and the rulemaking process cannot keep up with technological change, new scientific information, and the knowledge gained through accident and near-miss investigations. The safest workplaces go beyond mere compliance with the rulebook, and manage safety and health through a well-defined program focused on effective hazard identification and control. MSHA strongly recommends that all mines implement such "find and fix" programs. Yet how widespread are such programs? How effective are they? What are their characteristics? What are the impediments to successful programs?

Impact of the Research: Understanding the characteristics of and barriers to effective hazard identification and control programs is critically important for all workplaces, but particularly for more hazardous workplaces, such as mines. One-hundred-forty-two miners died from traumatic injuries in U.S. metal and non-metal mines between January 1, 2007 and October 19, 2013. Many more died from occupational disease or were seriously injured. The USW is the predominant union in metal and non-metal mining in North America, with members in 125 U.S. mines. The union is well-positioned to study the effectiveness of hazard identification and control programs in this industry. The miners represented by the USW are essential to these activities because they are more familiar with their work environment than anyone else, and because many deadly hazards are the result of unusual, changed or upset conditions which can only be identified by the miners actually present when they occur. Many organizations, including OSHA, MSHA, ANSI, and the ILO have outlined the elements of comprehensive safety and health management programs. Both OSHA and MSHA are considering standards mandating such programs. But little data exists on their prevalence, let alone the effectiveness of individual elements. A better understanding of what actually works should lead to more and better programs in metal and non-metal mines. The findings may be generalizable to other mines and other industries.

Objectives and Research Approach: The objectives of the study are to: 1) determine the prevalence of find-and-fix programs in USW metal and non-metal mines; 2) assess the role and effectiveness of safety and health committees in these programs; 3) measure worker participation in these programs and identify barriers to participation; 4) develop best practice recommendations to strengthen these programs and overcome obstacles to worker participation; and, 5) evaluate efforts to put these recommendations into practice. The research will begin with a survey of a stratified sample of the USW's metal and non-metal mines, sent to the union leadership and management counterparts in each location. This will be followed by an intensive survey of every miner and manager at five case study sites representing different commodities – tentatively iron, copper, trona, precious metals and salt. The surveys will be used to develop recommendations, which we will attempt to implement at the case study sites, and other sits as well.

Project Title: Implementation of Risk Management Programs: Identification of Best Practices to Reduce Injuries and Maximize Economic Benefits

Organization: University of Arizona
Partnerships: Professor Jim Joy, JKTech Pty Ltd
Carmel Bofinger, Minerals Industry Safety and Health Centre, Univ of Queensland
Dr. Dana Willmer, NIOSH Office of Mine Safety and Health Research
BHP Billiton New Mexico Coal
Barrick GoldStrike
Salt River Materials Group

Investigator(s): Dr. Jeff Burgess, PI
Dr. Eric Lutz, Co-PI
Dr. Gautam Gowrisankaran, Co-PI

Focus Area: Safety and Health Management

SYNOPSIS

Problem Statement and Justification: Mining remains a dangerous profession. Risk management is a cyclical process of identifying operations or activities at high risk for injuries, redesigning operating procedures to reduce risks, implementing these changes and evaluating their effectiveness. Internationally, risk management is a legal requirement in many countries, but in the U.S. safety and health regulations are generally compliance-based. Establishment of risk management in Australian mines has been associated with significant reductions in lost-time injuries, and, in preliminary studies, progressive U.S. mines have also reduced injuries after instituting formal risk management programs.

Impact of the Research: Our goal is to determine the effectiveness of risk management interventions in reducing injuries and economic costs in the U.S. mining industry. The proposed research will: identify risk management best practices for U.S. mining operations including determination of the effect of overall risk management programs and component parts on injury rates and return on investment (ROI); develop business cases to help move industry to adopt these interventions; identify critical risks and controls for industry use; and share these resources through a dedicated website.

Objective(s) and Research Approach: Our project objectives are to: 1) Evaluate current risk management implementation in the U.S. mining industry; 2) Determine intervention ROI and risk management best practices; and 3) Share risk management tools through a dedicated website. We will work with U.S. mine sites with extensive risk management expertise representing both metal and coal sectors. A risk management survey/data collection tool for scoring overall program implementation and individual risk management interventions will be developed. The survey results will be combined with retrospective longitudinal analysis of company internal data and Mine Safety and Health Administration (MSHA) reported injury claims to determine the effectiveness of implemented risk management interventions. We will also evaluate the costs of program implementation, including direct and indirect program costs and the resulting changes in injury costs. Risk management intervention best practices will be identified by reduction in injury rates and positive ROI.

Project Title: The Mining Healthy Workplace Program (MHWP)

Organization: University of Connecticut Health Center

Partnerships: University of Connecticut, Storrs Campus (CPH-NEW)
Viridian Health Management (VHM)
University of West Virginia Mining and Industrial Extension (WVUMIE)
West Virginia Board of Coal Mine and Health & Safety
James River Coal

Investigators(s): Martin Cherniack
Sharon Covert

Focus Area: Safety and Health Management Systems

SYNOPSIS

Problem Statement and Justification: The morbidity and mortality risks to Appalachian coal miners exceed those of many other working populations in the United States. There is controversy over etiology, whether risks are specific to coal mining, or reflect the general rural population. An Institute of Medicine Report in 2005 noted that there is often no precise division between exposures and risks that occur within and outside of the workplace. In 2011, the Center for Disease Control and Prevention (CDC) launched the National Healthy Worksite Program (NHWP) to introduce a more integrated approach to interventions in American workplaces involving work and health. This proposed Mining Healthy Worksite Program (MHWP) reflects a coordinated effort by multiple parties – public health bodies, academia, employers, and mineworkers -- to tailor the NHWP approach to mining and carry to out a year-long health enhancement intervention similar to those being introduced into other NHWP industries.

Impact of the Research: This project will revise the apprenticeship and recertification programs for West Virginia miners by introducing a more integrated health curriculum. Program staff will create the regional inventory of health resources similar to NHWP programs. The VHM, CPH-NEW, and WVUMIE project team will lead participatory wellness teams using a customized set of program materials for mining that include: a mining-specific form of the NHWP CAPTURE™ Health Risk Appraisal (HRA) that profiles individual health risks; the INPUTS™ all-employee survey that assesses health and safety climate; and the CDC Health Scorecard (HSC) that assesses organizational health supports.

Objective(s) and Research Approach: The proposed MHWP has four objectives:

1. Enhanced training: Develop, pilot test, and evaluate expanded health components of the mandatory health and safety curricula for prospective underground and surface miners, and introduce an enhanced health curriculum for the recertification of incumbent miners.
2. Intervention development: Adapt the integrated and participatory OSH and WHP intervention programs of the NHWP to the coal mining industry.
3. Intervention piloting: Introduce yearlong health improvement interventions at 4 mining sites, measuring baseline and follow-up health status of participants, and introducing an integrated, participatory onsite OSH/WHP program that includes personalized health coaching. Compare this with control mining sites receiving the enhanced health education and certification renewal program.
4. Intervention evaluation: Compare the relative costs and effectiveness of the two programs.

Project Title: Improved Safety through Application of Risk Management in US Underground Coal Mines: A RISKGATE Approach

Organization: Virginia Polytechnic Institution and State University

Partnerships: *Academic Research Partners:* The University of Queensland, and The University of New South Wales; *Supporting Industry Partners:* Anglo American Metallurgical Coal (AU), Arch Coal, Inc. (US), Centennial Coal Company, Ltd. (AU), Cliffs Natural Resources (US), Consol Energy, Inc. (US), Peabody Energy (US and AU)

Investigator(s): Kray Luxbacher (PI) and Nino Ripepi (Co-PI)

Focus Area: Safety and Health Management

SYNOPSIS

Problem Statement and Justification: Recent high profile mine accidents, including the Upper Big Branch Explosion in 2010, have highlighted the need for innovative and effective approaches to mine safety. While risk assessment and management is a well-recognized approach to improving and ensuring health and safety in a multitude of industrial and energy sector applications, including petroleum, nuclear, and mining industries it is seldom applied to the US coal mining industry. Risk management approaches allow for inclusive stakeholder engagement; innovation in management and technology, along with rapid integration; and ready identification and mitigation of risk, even if that risk is specifically identified through regulation.

Impact of the Research: This research has great potential for positive and substantial impact. Mining companies in the United States have robust, dedicated safety programs with zero harm goals, but are often driven by compliance with regulations. In some cases, these safety programs focus on root cause analysis, but this can be a flawed approach because it is often difficult to trace major accidents to a single root cause. The US regulatory framework was designed to create a safer mine environment in order to protect the miner, but the prescriptive nature of the law makes the application of more innovative techniques nearly impossible. The combination of safety compliance goals with a root cause analysis approach have made mines safer over time, but also makes the ultimate goal of reaching zero accidents unattainable.The proposed work on applying risk management procedures has great potential to reduce accidents and fatalities in the US underground coal mining sector, as well as the broader mining sector.

Objectives and Research Approach: The objective of this research is to examine how risk management approaches can be applied in a comprehensive manner to the US underground coal mining industry to improve mine safety. This will be accomplished through a partnership with two Australian universities as well as study and adaptation of an ambitious Australian research project: RISKGATE. Australia is widely recognized for progressive practice in mine safety regulation, and application of risk management. RISKGATE is an interactive online risk management system, sponsored by the Australian Coal Association Research Program (ACARP), which provides operators with a body of knowledge to assist in implementing risk management approaches in Australia. The aims of this research are to:

- Identify factors that could contribute to a change in risk management in the US.
- Develop strategies for implementation of risk management approaches in the US utilizing the RISKGATE body of knowledge.
- Apply these strategies to three high risk areas in US underground mine safety: Fire and Explosion Prevention, Ground Control, and Moving Equipment.
- Disseminate findings and recommendations for application of these strategies to the entire body of US underground mining health and safety topics, with implications for the rest of the US mining sector considered.

Project Title: Effective Mining Safety Training - Design, Implementation, and Evaluation

Organization: The University of Arizona

Partnerships: Louisiana State University (Reid Bates, Ph.D.)
BHPBilliton, Barrick Goldstrike
Resolution Copper, Salt River Materials Group
Vulcan Materials
Arizona Mine Inspector
Hazard Prevention Institute

Investigator(s): Mary M. Poulton
Eric A. Lutz

Focus Area: Training

SYNOPSIS

Problem Statement and Justification: More than $100B is spent by US companies each year on training. Further, mining companies spend millions of dollars each year on training, including MSHA-required courses such as annual refresher; yet illnesses, injuries, and accidents continue to occur. Research from other industries suggests that active learning can result in increased knowledge acquisition and reduction in health and safety incidents, but there is no data available specific for mandated mining safety training. The main objective of this study is to increase the effectiveness of mandated training. The project will provide guidance to mine trainers on how to modify existing training courses to include more active and engaging learning experiences while simultaneously meeting MSHA requirements. Refinement and validation of an instrument to measure the adult learning principles applied in this study will allow managers to evaluate their trainers and provide mine companies and regulatory agencies with a powerful tool to assess the quality of contractor- or vendor-led training courses.

Impact of Research: Mining companies will have access to a mining-specific 'handbook' of evaluated active learning exercises for use in mandated training courses. Coupled with this handbook, trainers and operators will have access to the train-the-trainer curriculum and materials for increasing the adult learning, active learning, and transfer of training knowledge to the job. The Andragogical Process Inventory, the first validated instrument to measure andragogical principles and process design elements that impact learner satisfaction and learning outcomes, will be validated for use by companies, federal agencies, and others. These tangible items can help mine companies design and implement better, more effective, training programs for their employees, validating the effectiveness of these trainings, and ultimately reducing the rates of occupational incidents, injuries and illnesses.

Objectives and Research Approach: We have partnered with both large and small mine operations representing major commodity sectors, a state agency, and a private training company, who cumulatively train more than 3,000 individuals representative of the broader mining community (e.g., young/old, new/experienced, native English speakers/English language learners, working in a variety of positions, from laborer-to-contractors-to-management, and across many commodity sectors in both surface and underground) and will therefore support the generalizability of our study outcomes. With these partners we are proposing to:

- Re-design existing mandated training courses using adult and active learning methodologies;
- Create and disseminate a handbook of active learning exercises;
- Design and implement a train-the-trainer course using active learning methodologies emphasizing transfer of training;
- Disseminate the train-the-trainer curriculum for use by the mining community;
- Validate and publish the Andragogical Process Inventory instrument for use in the mining;
- Compare the outcomes of the re-designed training courses with traditional training courses.

Project Title: Enhanced Mobile Equipment Experiential Learning and Safety Technology Demonstration

Organization: West Virginia University Foundation.

Partnerships: West Virginia Department of Miners Health, Safety & Training

Investigator(s): James M. Dean

Focus Area: Safety and Training

SYNOPSIS

Problem Statement and Justification: According to the Mine Safety and Health Administration, between 2000 and 2010 nearly 800 miners were injured and 6 killed in accidents involving shuttle cars and scoops in underground coal mines. Most of these accidents occur because the equipment operator is not aware of the presence of personnel near the mine equipment. Despite the availability and delivery of specific training on the dangers presented by mobile underground mining equipment, accidents involving mobile equipment continue to be a significant share of total fatal and non-fatal accidents in underground coal mines.

Impact of the Research: Machine mounted cameras and proximity detection systems can improve the ability of equipment operators to know when individuals may be in harm's way, but without proper training, there may be a tendency for operators to rely too much on this technology and neither represents a failsafe system. Realistic experiential training, for operators and apprentice miners, is needed to fully impart the dangers presented by mobile equipment, the limitations of any technological West Virginia Department of Miners Health, Safety & Training aids, and best safety practices by everyone to reduce significantly the number of accidents involving mobile equipment. West Virginia University Mining and Industrial Extension (MIE) propose to create and provide the research based experiential training necessary to improve the safe operation of shuttle cars and scoops in underground coal mines.

Objective(s) and Research Approach: The first specific aim will be the creation of the key components of the demonstration and curriculum. The startup committee of three equipment operators and three management representatives will provide coverage of areas of concern that have not been addressed to the point that the decision to implement the technology can be made. This information will be used to formulate a training curriculum to address these weaknesses. The second specific aim will be to execute the training curriculum which will include training exercises at the simulated mine facility by various parties, and demonstrations for industry, research organizations, and government regulators. The third specific aim will be to provide evidence that the training conducted as part of this effort has been effective. The Investigator will follow the model described in NIOSH publication No. 99-142 *A Mode/for Research on Training Effectiveness or Training Intervention Effectiveness Research (TIER)* as a guide to for the effectiveness assessment.