Mine Workers and Mine Health and Safety
Annotated Bibliography

The purpose of this annotated bibliography is to provide a summary of studies relevant to the CLEAR Mine Workers and Mine Health and Safety topic area. The studies were identified during a comprehensive literature search described in the topic area review protocol. The summary of each study includes the citation, keywords, research objective, description of the intervention/equipment, methodology, outcomes, analyses, and findings. Due to the study designs, the studies could not be evaluated according to CLEAR Causal Evidence Guidelines. Therefore, these studies were not reviewed for the strength of causal evidence.

The studies test numerous engineering controls that are designed to improve overall mine safety and prevent fatalities and illnesses among mine workers. The engineering controls are comparable to those included in the Mine Workers and Mine Health and Safety topic area:

- Atmospheric monitoring
- Communications
- Escape and emergency evacuation
- Explosion suppression
- Fire warning and fire suppression
- Flame resistance
- Ground control
- Hearing protection
- Proximity detection systems
- Respiratory devices

This annotated bibliography contains the summaries of 17 studies, organized in alphabetical order by author.

Alexander, B.M., Esswein, E.J., Gressel, M.G., Kratzer, J.L., Feng, A.H., Miller, A.L., Cauda E., & Heil G. (2018). Evaluation of an improved prototype mini-baghouse to control the release of respirable crystalline silica from sand movers. *Journal of Occupational and Environmental Hygiene, 15*(1), 24-37. https://doi.org/10.1080/15459624.2017.1376068

KEYWORDS: Respiratory devices

RESEARCH OBJECTIVES: The study's objective was to test the effectiveness of the 3rd generation National Institute for Occupational Safety and Health (NIOSH) Mini-Baghouse Retrofit Assembly (NMBRA) in reducing respirable dust and crystalline silica (RCS) among hydraulic fracturing workers. The NMBRA controls respirable crystalline silica (RCS) emissions by passing dusty air through a suspended filter bag; the filter bag acts as a substrate for formation of a dust cake, which collects the suspended particulates. The air pressure produced by the pneumatic transfer of sand from delivery trucks to sand movers is used to inflate the suspended filters, on which the dust cake forms and filtration occurs.

METHODOLOGY: The authors evaluated the performance of eight, 3rd generation NMBRA units installed on a National Oilwell Varco APPCO FS-30 frac-sander (i.e., sand mover). A total of 168 air samples were collected during two days of sampling. Half of these samples (84) were collected with the NMBRA installed, and half (84) were collected when the NMBRA was absent. Seven two-part trials were conducted; one part consisted of filling the sand bin with the NMBRA present, and the other with the NMBRA absent. Air samples were collected for the length of time required to transfer one truckload of sand into the sand mover bin. Air samples were collected at 12 sampling locations. All samples were analyzed for respirable dust and RCS according to NIOSH Methods 0600 and 7500 at an American Industrial Hygiene Association (AIHA) accredited, NIOSH contract analytical laboratory.

FINDINGS: The study found substantial reductions in respirable dust and RCS in the sample with the NMBRA installed. Reductions in respirable dust were all estimated by the maximum likelihood estimation method to be 99+ percent. Researchers suggest additional field evaluations and a company partnership to commercialize this technology.

Bealko, S. B. (2009). *Mining haul truck cab noise: An evaluation of three acoustical environments* (CDC Publication No. NIOSHTIC2 20036005). The National Institute for Occupational Safety and Health.

KEYWORDS: Hearing protection

RESEARCH OBJECTIVES: The main objective of the study was to compare the effectiveness of old, retrofitted, and new haul truck cab enclosures in reducing limestone worker's exposure to hazardous noise.

METHODOLOGY: Criteria were developed to classify cabs into three categories: old-style cabs, new-style cabs, and retro-fitted cabs. Twenty-five haul trucks were examined, including 5 old-style, 17 new-style, and 3 retro-fitted cabs. Pre-shift, each cab underwent maintenance inspection and drivers were interviewed about their habits, activities, and common practices. Noise dosimeters were attached to cabs to measure 8-hour time-weighted average pressure sounds inside and outside of the cabs during normal shifts. In all, 44 samples were collected over the 13-shift study period.

FINDINGS: Results indicated most noise levels outside of all three cab categories were above the Mine Safety and Health Administration (MSHA) permissible exposure limit (PEL), with 43 out of 44 (98%) measurements inside cabs were below the MSHA PEL regardless of cab style, cab maintenance condition, or differences in associated co-variables. Nonetheless, researchers suggest noise reduction measures should be taken to reduce noise even further to prevent noise-induced hearing loss.

Bochorishvili, N., Chikhradze, N., Mataradze, E., Akhvlediani, I., Chikhradze, M., & Krauthammer, T. (2015). New suppression system of methane explosion in coal mines. *Procedia Earth and Planetary Science, 15*, 720-724. https://doi.org/10.1016/j.proeps.2015.08.102

KEYWORDS: Explosion suppression

RESEARCH OBJECTIVES: The study aimed to test the effectiveness of a new protective system developed by both the G. Tsulukidze Mining Institute and the Center for Infrastructure Protection and Physical Security (CIPPS). The overall purpose was to develop a more effective counter-explosion system to reduce the number of fatal methane and coal dust explosions. New developments in this system include 1) a wireless explosion detection device, and 2) a pyrotechnic absorber capable of activation without an external power supply, and quick discharge of water through nozzles for dispersed water formation.

METHODOLOGY: Testing was conducted in an underground experimental tunnel. Testing tunnels had a height of 2.2 m, width of 2.2m, and total length of 150 m, supported by reinforced concrete. The authors conducted two stages of testing: one using a horizontal absorber and another using a vertical absorber; the wireless explosion detection device was used in both stages. The vertical absorber was tested at a charge weight of W=4kg, 5m charge to sensor distance, and 2m mist width. The horizontal absorber was tested at a charge weight of W=2kg, 4m charge to sensor distance, and 2m mist width. Over-pressures were measured by means of three sensors fixed at 0.6, 1.2. ad 1.8 m from the tunnel floor, respectively. With the aim of controlling time characteristics, a blast moment, an absorber activation moment, and shock wave arrival under the explosion of a 3kg charge at the distance of 15 m from the absorber were recorded. A pressure sensor was installed in an absorber container and connected to an oscilloscope to record peak pressures generated in a hydro system after the activation of a gas generator.

FINDINGS: The study found that both the horizontal and vertical absorbers in the new protective system reduced maximum overpressures at both 2kg and 4kg charge weights across all three sensors. The greatest reduction in shock wave overpressure resulted from the use of a horizontal absorber for an average reduction of 75 and 198 units, respectively.

Brown, C. B. (2017). *Investigation of coal dust remediation using a surfactant in an aqueous solution* (Unpublished master's thesis). Virginia Polytechnic Institute and State University, Blacksburg, VA.

KEYWORDS: Respiratory devices

RESEARCH OBJECTIVES: The study's objective was to test the effectiveness of a surfactant to improve the wettability of coal dust, and subsequently decrease the dust concentrations to which miners would be exposed.

METHODOLOGY: The author conducted an experiment over a two-week period in an underground bituminous coal mine utilizing room and pillar mining techniques**.** First, pipes were flushed with regular mine water to ensure previously used surfactants were completely washed out. Then, the experimental surfactant was mixed into the pipe water and released onto dust. A hanging submerged platform was used to measure the amount of wetted dust placed on the surface of the water and surfactant solution. The Thermo Scientific PDM3600 and the Sefron Escort ELF Personal air sampling pump were used to gather data on the wettability of the dust with and without the surfactant. As the measurements were taken at known time intervals, a wetting rate was derived.

FINDINGS: The researchers found the surfactant had no observable impact on the wetting rate of the dust. They also found wetting rates for dust with higher mineral contents increased at faster rates than those with primarily coal dust. Researchers called for more tests to determine the effectiveness of the surfactant on high gravity dust and further research using scanning electron microscopy (SEM) analysis to accurately determine true mineral content.

Carr, J. L., Reyes, M. A., & Lutz, T. J. (2014, February). *Underground field evaluations of proximity detection technology on Continuous Mining Machines*. SME Annual Meeting, St. Lake City, UT, United States.

KEYWORDS: Proximity detection systems

RESEARCH OBJECTIVES: The study aimed to test the effectiveness of a proximity detection system in automatically disabling Continuous Mining Machine (CMM) motion. The overall purpose was to develop technology capable of preventing injury/fatality among miners by CMMs.

METHODOLOGY: Testing was conducted on three CMMs at three field sites. Two different Mine Safety and Health Administration (MSHA)-approved proximity detection systems were involved in this test though they were not distinguished in the methodology. Thus, researchers suggest interpreting the results as general observations of proximity detection technology performance. Researchers at the Office of Mine Safety and Health Research (OMSHR) used a custom measurement apparatus to characterize the warning zone and stop zone distances of CMMs by moving a personal wearable device (PWD) towards the machine until a PWD alarm was activated. Researchers recorded the distance at which the alarm was activated for the warning zone and proceeded to move towards the machine until an alarm was activated for the stop zone. This was executed at 10 specific test points around the perimeter of the machine. All measurements taken during these tests were performed in fresh air.

FINDINGS: The authors found proximity detection systems provided consistent protection across a wide variety of conditions including PWD height, PWD orientation, and close proximity to trailing cables. However, tramming tests showed the potential for issues with detection. Researchers at OMSHR intend to continue working with proximity detection manufacturers to further investigate proximity detection technology and improve the performance of future systems.

Damiano, N. W., Li, J., Zhou, C., Brocker, D. E., Qin, Y., Werner, D. H., & Werner, P. L. (2016). Simulation and measurement of medium-frequency signals coupling from a line to a loop antenna. *IEEE Transactions on Industry Applications*, *52*(4), 3527-3534. https://doi.org/10.1109/TIA.2016.2535979

KEYWORDS: Communications; Escape and emergency evacuation

RESEARCH OBJECTIVES: The study's objective was to present the simulation and measurement results of recent National Institute for Occupational Safety and Health (NIOSH) research aimed at investigating medium frequency (MF) coupling between a transmission line (TL) and a loop antenna in an underground coal mine. The overall purpose was to explore MF technology as a means to ensure communication between underground and surface personnel, and electronic tracking of all underground mine workers in compliance with the Miner Improvement and New Emergency Response Act of 2006.

METHODOLOGY: The authors completed two different types of measures: 1) line-current distribution and 2) line-to-antenna coupling. Measurements were conducted underground in an experimental coal mine and on a specially designed surface test area.

FINDINGS: The authors found several issues for MF TLs including electromagnetic fields at the ends of the TL, the effect of other underground conductors, and the proximity of coal or Earth. Researchers suggest resolving the issue of diminishing electric signals near the end of TLs by extending the TL beyond the beginning and end points of maximum transmission.

Dougherty, H. N. (2018). *Evaluation and design of atmospheric monitoring interfaces and approaches for improved health and safety in underground coal mines* (Unpublished doctoral dissertation). Virginia Polytechnic Institute and State University, Blacksburg, VA.

KEYWORDS: Atmospheric monitoring; Explosion suppression

RESEARCH OBJECTIVES: The study had two objectives: 1) to survey existing underground mining interfaces, and 2) to research, create, and evaluate a prototype atmospheric monitoring interface. The overall purpose was to create an interface capable of providing real time information to miners and technology personnel in an intuitive way such that they are equipped to make more educated and informed decisions regarding their safety.

METHODOLOGY: To meet the first objective, the author examined two interfaces from different companies that service mines for sensor and networking needs. The author then leveraged this research to create and evaluate an improved atmospheric monitoring interface named ADAMAS. To do this, the author collected the mine's atmospheric monitoring data and adapted this for the atmospheric monitoring system (AMS) interface simulation. Touchscreen tablets were used to assist in an interactive environment and allowed multiple participants to interact with the interface individually. A pre-interface survey was administered to participants where they reported information regarding their demographics, AMS knowledge, and feelings about AMS and the interface. Post interface questionnaires were given to participants to provide feedback on their experience with ADAMAS.

FINDINGS: The researcher found current interface systems were not accessible to miners, or persons with colorblindness. The author suggested ADAMAS would resolve these issues by presenting visual data that is easily accessible for more informed decision making. Post-interface surveys indicated miners, regulatory personnel, and management see value in this system for themselves and operation.

Li, J., DuCarme, J., Reyes, M., & Smith, A. (2018). Investigation of the influence of a large steel plate on the magnetic field distribution of a magnetic proximity detection system. *Mining Engineering, 70*(6), 51-56. https://doi.org/10.19150/me.8299

KEYWORDS: Proximity detection systems

RESEARCH OBJECTIVES: The aim of this study was to test the influence of steel mass on the magnetic field distribution of magnetic proximity detection systems. The overall purpose was to improve mine worker safety by increasing the performance and reliability of electromagnetic proximity detection systems by understanding how steel mass found in mining equipment could be affecting the locational accuracy of these systems.

METHODOLOGY: To examine the influence of steel, two magnetic field distribution models were obtained from two experimental setups, one with and one without a large steel plate placed near the generator. A total of 495 measurements at different points around the generator were collected for both experimental setups.

FINDINGS: Researchers found the presence of steel mass strengthened the magnetic field perpendicular to the generators by up to 40 percent. Furthermore, they found the degree of the influence on the field distribution to be a function of distance. Ultimately, they suggested these findings could be used to ensure more accurate modeling of the magnetic field distribution and design of a proximity detection system generator circuit.

Martikainen, A., Taylor, C., & Grau, R. (2010, February 28-March 3). *Studying intake airway pressurization by ventilation modeling and leakage evaluation.* SME Annual Meeting, Phoenix, AZ, United States.

KEYWORDS: Escape and emergency evacuation

RESEARCH OBJECTIVES: The study's aim was to evaluate the role of ventilation modeling as a tool for planning the pressurization of intake entries in coal mining escapeways. The overall purpose was to assure that workers could safely use the intake airway to escape a coal mining section in the event of fire or other emergency in which hazardous contaminants are produced in the belt entry.

METHODOLOGY: The authors tested the ability of three different software packages (Program A, Program B, and Program C) to predict the prevalence of leakage while using a fan at baseline, low, medium, and high settings. For each model, they recorded pressurization data - a key element of leakage prevention. Then, they replicated the four model scenarios in an actual intake airway and once again, recorded pressurization data. Finally, they compared the results of the modeling scenarios with the airflow measurements.

FINDINGS: The authors found Program C to be the most effective across all four models; this software had the least deviation from airway results across all four fan settings. Furthermore, barometric pressures in the entries were almost identical without the effect of the free-standing fan, while low fan settings correlated with higher leakage.

Novak, T. (2016). *The application of flooded bed dust scrubbers to longwall mining systems* (Grant No. AFC113-10). University of Kentucky.

KEYWORDS: Respiratory devices

RESEARCH OBJECTIVES: The study's objective was to evaluate the effectiveness of incorporating flooded-bed dust scrubbers into a shearer to capture and remove respirable and float dust in longwall mining systems. Excessive inhalation of both respirable and float dust can result in coal workers' pneumoconiosis (CWP), a debilitating lung disease also known as black lung. The Alpha Foundation for the Improvement of Mine Health and Safety used research grants to address the health and safety of mine workers by specifically examining various experimental factors on dust capture effectiveness to reduce the amount of respirable and float dust from longwall mining.

METHODOLOGY: To conduct the study, the Department of Mining Engineering at the University of Kentucky designed and fabricated a full-size mockup of a longwall Joy 7LS double-drum shearer with an integrated dust scrubber. The Longwall Dust Gallery at the NIOSH Pittsburgh Research Laboratory was used as the site to install the shearer mockup, because of its ability to replicate a portion of an actual longwall mine and generate respirable dust that is produced by a shearer while cutting coal. The author evaluated the effectiveness of the flooded-bed scrubber with respect to dust capture and removal. A series of 40 tests were conducted measuring dust-dust levels with ThermoFisher Scientific Personal Dust Monitors. The experimental conditions consisted of three factors, two levels, six different locations, and five replications. The three factors at two levels included: scrubber inlet (with and without extension), scrubber capacity (high level 60Hz and low level 30Hz), and face air velocity (high level 700fpm and low level 500 fpm). The author also evaluated dust reduction with the splitter arm spray ON and OFF, however, they focused their results while the splitter arm sprays were OFF, because the focus of the analysis was on the effectiveness of the scrubber. Regression analyses were run on each condition to evaluate the performance based on the percentage of dust reduction.

FINDINGS: The study found that a flooded-bed dust scrubber integrated into a shearer was effective in reducing the amount of respirable dust levels in the air. This was true when the splitter arm sprays were ON or OFF; however, the difference in performance was minimal (62.5% vs 56.4%, respectively). In the location of the return, the scrubber performance was best under the following conditions: inlet extension included, scrubber at maximum capacity, and face velocity at 700 fpm (3.56 m/s). The study found the most significant factor was the scrubber capacity. The scrubber was also found to reduce dust concentrations in the longwall walkway without the assistance of splitter arm sprays by up to 74 percent.

Orr, T. J., Mallet, L. G., & Margolis, K. A. (2009). Enhanced fire escape training for mine workers using virtual reality simulation. *Mining Engineering*, *61*(11), 41-44.

KEYWORDS: Escape and emergency evacuation; Fire warning and fire suppression

RESEARCH OBJECTIVES: The study's objective was to test the effects of the Virtual Reality Miner Safety Training (VRMST) software on time to identify evacuation routes. The VRMST software simulates a mine fire and allows participants to practice evacuation procedures and identify evacuation routes.

METHODOLOGY: Thirty-two participants were assigned to one of eight groups (four participants per group). Each group was required to navigate through two scenarios: a simple escape scenario and a complex escape scenario. The order of the scenarios was counterbalanced to avoid order effects. The authors recorded the time for completion of each scenario for each group. However, the authors did not conduct tests of statistical significance; they provided descriptive analyses.

FINDINGS: The study found that the groups that completed the simple scenario first completed the complex scenario 37 percent faster than those completing the complex scenario first. No differences were found in the completion times between the groups for the simple scenario regardless of order of presentation.

Perry, K. A., & Meyr, R. A. (2016). Explosion testing of a polycarbonate safe haven wall. *Archives of Mining Sciences*, *61*(4), 809-821. https://doi.org/10.1515/amsc-2016-0055

KEYWORDS: Fire warning and fire suppression; Ground control

RESEARCH OBJECTIVES: The study's objective was to test the effects of a polycarbonate safe haven wall system on structural safety and explosion blast resistance. The overall purpose was to develop an alternative refuge option to help protect trapped miners unable to escape a mine explosion. The polycarbonate safe haven wall system was 20 feet long and 6 feet high and consisted of 14 hollow structural sections (8 × 4 × 0.625 inch) vertical supports held in place by a C10 × 30 channel at the top and bottom. One-inch-thick polycarbonate panels were placed on either end of the wall and four middle panels were bolted on the outside of the frame.

METHODOLOGY: The authors conducted four explosion tests, with pressure sensors placed on different areas of the wall. The authors also collected pressure measurements and deflection data of a specified point on the wall. Comparisons were made between actual and modeled pressure versus time waveforms.

FINDINGS: The study found that the safe haven wall was capable of withstanding multiple blasts up to 176.23 kPa. However, this pressure versus time waveform did not meet MSHA regulation.

Rowland, J.H. III., & Smith, A.C. (2012). *Flammability of wider conveyor belts using large-scale fire tests* (CDC Publication No. NIOSHTIC2 20040464). The National Institute for Occupational Safety and Health.

KEYWORDS: Flame resistance

RESEARCH OBJECTIVES: The aim of this study was to test whether the modern use of wide conveyor belts – which on average measure 183 cm – meet flame resistance requirements initially set forth by the 2006 Belt Evaluation Laboratory Test (BELT) which used conveyor belts with average widths of 91-107 cm.

METHODOLOGY: Researchers tested 6 different types of 183 cm-wide conveyor belts deemed acceptable by different flammability standards. Experiments were conducted in the NIOSH Fire Suppression Facility (FSF) located in Fairchance, Pennsylvania. Two video cameras recorded each test burn (one mounted in the center of the roof and the other facing the open end of the tunnel). The conveyor belt structure was located 26 m (85 ft) from the fan. Test fires were ignited and allowed to flow for 10 minutes until extinguished. The belts were allowed to burn until they were just smoldering, had no visible flame, or until the entire length of the belt had been consumed by the fire. Belts passed the test if, in two separate trials, a portion of the belt remained undamaged across the entire width.

FINDINGS: Experimental tests of the 183 cm belts in the FSF were comparable to the 2006 large- scale test results of using 91-107 cm wide conveyor belts. Researchers point to the need for continued testing of large-scale experimental studies to ensure the correlation between the BELT method and the conveyor belt resistance is maintained as conveyor belts get wider in response to increasing coal hauling capacities.

Rowland, J. H., Verakis, H., Hockenberry, M. A., & Smith, A. C. (2011). Effect of air velocity on conveyor belt fire suppression systems. *Trans Soc Min Metall Explor, 328*, 493-501.

KEYWORDS: Fire warning and fire suppression

RESEARCH OBJECTIVES: The objective of this study was to study the effect of air velocity to extinguish conveyor belt fires. Four different types of suppression systems were used to gather results.

METHODOLOGY: The four different types of suppression systems were water, sprinkler, deluge-type water spray, and two different dry chemical fire suppression systems. Large scale fire tests were conducted with 72-inch-wide fire-resistant rubber belts.

FINDINGS: The large-scale testing indicated that the air velocity does in fact have significant effect on the detection, activation, and suppression capabilities of the fire suppression system. The water-based fire suppression systems each performed well under both sets of air velocity conditions but required more time than the 10-minute requirement in 30 CFR. The dry chemical systems, however, did not perform as well, and resulted in failure to extinguish the test fires in some experiments.

Tessum, M. W. (2015). *Effects of spray surfactant and particle charge on respirable dust control* (Doctoral Dissertation). Retrieved from https://conservancy.umn.edu/handle/11299/175351

KEYWORDS: Respiratory devices

RESEARCH OBJECTIVES: The author analyzed the efficiency of surfactant-containing spray characteristics in the ability to catch monodisperse polystyrene latex particles and polydisperse coal dust to reduce coal dust concentration in mines. Respirable coal dust has been associated with pneumoconiosis in coal workers (black lung). Characteristics tested included particle size, aerosol charging condition, the type of surfactant, particle and spray drop charge, and spray surface tension and drop size.

METHODOLOGY: The author used an apparatus with a wind tunnel to test the collection efficiency of the surfactant spray with multiple rounds of experiments. The characteristics (such as particle size, particle charge) collection efficiency were statistically analyzed using analysis of variance and regression.

FINDINGS: The author found that the particle size of a water-based spray had an impact on the ability to efficiently contain the respirable dust. Additionally, highly-charged particles were removed more efficiently than particles that were weakly-charged. The author also found a positive correlation with magnitude of spray drop charge and spray collection efficiency as well as nonionic surfactant-containing spray, which was also correlated with a higher likelihood of capturing respirable dust than the other sprays. Finally, the author notes that adding electrical charges to particles also improves efficiency of surfactants.

Trevits, M. A., McCartney, C., & Roelofs, H. J. (2009). Testing and evaluation of an inflatable temporary ventilation control device. Retrieved from https://pdfs.semanticscholar.org/b3e2/761b89498729a512d03828e912e11a7a11db.pdf?_ga=2.13432564.215097564.1596669188-453973577.1596669188

KEYWORDS: Fire warning and fire suppression

RESEARCH OBJECTIVES: The objective of this study was to test the sealing capability of Ventstop as part of an ongoing mine fire control and suppression research program. Ventstop is a multi-purpose, inflatable device that is produced by Minvent Solutions and is available for world-wide use in the metal and non-metal mining industry.

METHODOLOGY: Researchers conducted deployment, multi-day inflation, and air leakage tests at the NIOSH Lake Lynn Laboratory to determine the capability and limitations of Ventstop in a simulated coal mine setting. During the tests, Ventstop was subjected to low level forces of a nearby gas ignition.

FINDINGS: Air leakage tests showed that the unit could provide an effective temporary mine seal that could be further enhanced through the application of a polyurethane sealant.

Trevits, M. A., Thibou, M., Mucho, T. P., & Hatch, G. (2009, February 22-25). *Use of pressure swing adsorption technology to inert sealed mine areas with nitrogen.* SME Annual Meeting, Denver, CO, United States.

KEYWORDS: Explosion suppression

RESEARCH OBJECTIVES: The objective of this study was to create a reliable in-mine mobile plant that would extract Nitrogen gas (N2) from the mine atmosphere and use the gas to create and maintain a safe sealed mine area. Development of the pressure swing absorption (PSA) N2 plant was based on a design using pressure swing absorption technology and was sized to fit on a standard shield car or mine dolly for easy transport in and around an underground mine.

METHODOLOGY: Researchers selected a 62,000 ft. area of the NIOSH Safety Research Coal Mine (SRCM) to be sealed and rendered inert by the PSA plant. This area included two long entries with six intervening cross-cuts. The area was isolated from the rest of the mine by an existing three-foot concrete seal. To observe the progress of the inerting process, a gas sampling area was installed in the area to be sealed. Then, two tests were conducted. The first test was designed to determine if the PSA plant could render the sealed mine area inert and if the inert environment could be maintained. The second test was designed to determine if the PSA plant could render the sealed mine area inert, maintain the inert environment, and to also observe inerting frequency and duration as well as the time period between cycles.

FINDINGS: The authors found the PSA N2 system could successfully reduce the oxygen concentration in the sealed mine area and maintain an inert gas environment. They suggest more testing be done on the system to fully understand its capacities and limitations.