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Annual Report of Studies Being Considered and Conducted by West Virginia Department of Environmental Protection Office of Explosives and Blasting December 31, 2012

This report is being submitted by the Office of Explosives and Blasting (OEB) to the Joint Committee on Government Finance in accordance with the requirement of Chapter 22, Article 3A, Section 10(b). Below is a summary of the various research projects the OEB is currently working on or may work on in the future. The status of the various projects is discussed below.

Airblast Predictability

In 2009, the OEB started research dealing with the predictability of airblast by acceptable methods using data related to blasts at surface coal mines in West Virginia. Air Blast, as defined under the West Virginia Surface Coal Mining and Reclamation Act Title 199-2.2, is "an air-born shock wave resulting from the detonation of explosives" and is measured by specially designed blasting seismograph microphones in pounds-per-square-inch (psi) and reported in decibels (dB). Airblast can be a significant adverse effect of blasting. Typically, adverse effects of blasting are associated with ground vibrations and the related damage potential. The OEB receives many complaints from citizens that their homes are being shaken by blasting. Upon investigation it has often been determined that blasting ground vibrations should not be the cause of the complaints and that the complaints are more likely airblast related. This observation, coupled with increased incidents of airblast violations, led the OEB to examine the predictability of airblast and to reconsider current seismograph monitoring requirements.

The United States Bureau of Mines (USBM) developed scaled distance factors for ground vibrations; these are used to regulate blasting in West Virginia. These regulations are intended to protect low-rise residential structures from blast damage caused by ground vibration. The USBM also established a relationship for predicting airblast by modifying this scaled-distance equation using the cube root function of the explosive charge. This cube-root scaled-distance equation has never been written into federal or WV blasting regulations like the square-root scaled-distance has for ground vibration. Predictive airblast equations are marginally reliable if good blasting techniques are followed. However, undetected geological conditions and atmospheric conditions can have adverse effects on the airblast propagation.

The design, location, and performance of the shot, along with detailed local weather conditions, are needed to use the predictive airblast equations for evaluation. Preliminary review of the data collected appears to show that inclement weather alone can cause an airblast increase of 6-12 dB versus blasting on a clear weather day. The earlier sampling of some of these parameters was not easily verifiable. Additional data needed to be collected to verify these variables with an adequate sampling.

The field work for this preliminary research report was concluded in 2010. Data analysis was completed in 2011 and peer review of the draft report on those findings was completed in 2012. The final research report for this project has been completed and will be posted on the OEB webpage.

To verify the applicability of the 2009-10 findings, additional airblast data was collected in 2011 and 2012 at five WV mines. The 2011 data clarifies and confirms the conclusion about inclement weather in the preliminary report. A draft report of this additional data will be completed and sent out for peer review in 2013.

Comparison of Electronic Detonators vs. Conventional Pyrotechnic Delay Detonators

A study was funded by the federal Office of Surface Mining, Reclamation and Enforcement (OSM) and conducted by Dr. Braden Lusk, a professor at the University of Kentucky. The purpose of the study is to evaluate the performance of electronic detonators (blasting cap) as compared to conventional non-electric pyrotechnic delay detonators at a West Virginia coal mine. The OEB provided three of the ten seismographs being used in the study and assisted the research team in dealing with mine personnel, as well as deployment locations and installation of the seismographs.

Typically, conventional detonators have inherent errors commonly referred to as "cap scatter." This cap scatter error can be as high as +/- 10% of the designed millisecond (ms) delay interval of the detonator. Electronic detonators use relatively new technology and manufacturers claim low cap scatter (less than 1 per cent of their millisecond delay). Apparently, no independent studies have been conducted to substantiate this claim.

The first phase of this project involved controlled measurement of pyrotechnic and electronic cap scatter while concurrently developing a baseline of data by monitoring of non-electric blasts to get vibration parameters for the blast area at a WV coal mine.

The second phase of the project involved planning various shots using different timing configurations with electronic detonators, and compiling ground vibrations and fragmentation data and comparing the electronic blasts to the blast data collected using non-electric pyrotechnic detonators.

The OEB is not responsible for gathering or analyzing the data collected, however, the OEB will receive the data collected along with the final research report. A draft report has been submitted to the OSM and it is forecast that the final report and conclusions will be published in 2013.

Influences of Geophone Coupling on Seismograph Monitoring

Blasting vibrations are measured by specially designed seismograph geophones that measure vibration in three mutually perpendicular directions and report the results as a particle velocity wave-form in inches-per-second. Federal and West Virginia laws regulate the maximum level of vibration to prevent damage to structures.

In 2008, the OEB assisted Dr. Cathy Aimone-Martin in an OSM-sponsored study monitoring surface mine blasts at multiple mine sites in West Virginia and in other states. The purpose of this study was to investigate the influence of geophone placement and orientation on seismograph recordings. The OEB assisted by providing field support but did not control the accumulation of the data. No final report has ever been published on this project. Therefore, the OEB proposed a project that will revisit the different geophone mounting methods and the variance of vibration recordings resulting from those methods. A preliminary study was started in 2012 that was deemed necessary before repeating aspects of the Aimone-Martin study. This study is discussed in the next paragraph. Dr. Aimone–Martin presented preliminary data from her research at a blasting regulator's meeting in July 2012 and her final report is still pending.

As stated above, the OEB has gathered data for the preliminary stage of the study that was deemed necessary before attempting to duplicate aspects of the Aimone-Martin study. The OEB study gathered baseline data on 5-6 geophones mounted identically side-by-side in the ISEE preferred manner of buried and spiked. The data has been analyzed and it was concluded that data is needed for vibration levels over 0.7 inches. Once this data has been collected and analyzed, a report of the conclusions will be generated.

Comparing Seismographs of Different Manufacturers

The Appalachian Blaster Certification Delegation (ABCD) began a study in July of 2012 to compare seismographs from different manufacturers. Seven to nine seismographs from four different manufacturers were mounted approximately two feet apart in the preferred method of burying the geophones. The OEB selected the first monitoring location at a WV coal mine. The second monitoring location was at an Ohio surface coal mine. The third location was at a Maryland coal mine. A fourth comparison is planned for a blasting site in Pennsylvania. The OEB has been compiling and analyzing this ADCD data.

West Virginia Air Quality Assessment Near Surface Coal Mine Blasting

In February 2012, the state Department of Environmental Protection, in response to coalfield citizens' concerns regarding air quality near surface mine blasting sites in West Virginia, commissioned a two-week ambient air quality study in Clear Fork, Raleigh County. It was determined from sampling data that the local air quality was well within applicable health-based standards and there was not any conclusive evidence of impact of blast emissions on air quality in the study area.

The air quality study was conducted by Columbus, Ohio-based Battelle Memorial Institute at a cost of $249,000. The Battelle Memorial Institute is a non-profit global research and development organization with clients in both government and industry worldwide.

Two comprehensive primary monitoring sites were located at Clear Fork Elementary and at a local residence, and a third meteorological-only site was located at a nearby surface mine. Data collected at the sampling locations was used to determine ambient air concentrations and to compare results to historical levels and regulatory/health-based standards. Among the pollutants of concern were particulate matter (PM), carbon monoxide (CO), nitrogen oxides (NO/NO2/NOx), and volatile organic compounds (VOCs).

During the two-week study period, a total of 37 blasting events were carried out on two different surface mine permit areas near Clear Fork. During that time frame, monitoring of local meteorological conditions, volatile organic compounds and metals, as well as the characterization of different size fractions of airborne PM and of a variety of gaseous air pollutants, occurred.
The DEP believes that the two-week study is an important step in giving the agency a clearer picture of air quality near surface mine blasting sites and addressing the concerns of coalfield citizens. The entire study is available on the OEB web page.

Future Project

Microphones in Protective enclosures

In order to ensure consistent recording between different seismographs, The *ISEE Field Practice Guidelines For Blasting Seism*ographs – 2009 Edition was adopted as the main guide used for seismograph deployment. These ISEE guidelines do not address the mounting of microphones inside protective enclosures

The placement of microphones in protective permanent enclosures has been a topic of concern to regulators. This practice is very common in West Virginia, due to accessibility problems caused by West Virginia topography. Often times a house being monitored with a seismograph may be only 1000 ft from the blast, but because of the steep terrain, it is not safely accessible on foot from the blast area, and it might be a forty-minute drive away. Because of the time involved in accessing the seismograph data after each blast and the high cost of the seismograph unit, it is common to see seismographs placed in locked enclosures with the microphone placed inside the enclosure and the geophone buried in the ground below the enclosure. In long term installations, the enclosure is often placed on embedded steel poles to keep it above snow accumulation levels, to give line of sight access to satellites for remote downloading, and allow the solar panel battery recharging system to access more sunlight. Most enclosures have ventilation holes and it is assumed that this ventilation provides adequate access to the outside atmosphere for accurate recording of airblast.

This project is designed to address enclosure concerns by placement of blasting seismograph microphones outside and next to the most common types of active monitoring stations with microphones in enclosures, in order to compare the airblast response of the enclosed units to open units. Additional monitoring of less common type, protective enclosures with various ventilation designs will be maybe compared. If appropriate, the OEB will recommend new guidelines for use of protective enclosures depending on study results. This project is forecast for startup in 2013.