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Title: Numerical Tools for Mitigation of Methane Explosions in Coal Mines

Organization: University of Maryland

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Partnerships: Naval Research Laboratory

Focus Area: Health and Safety Interventions
Topical Area: Fire and Explosion Prevention

Problem Statement and Justification: Accidental gas explosions in coal mines are low-probability, high-impact events that cause devastating losses of both human life and property, in addition to having a strong impact on the mining industry. These explosions are usually caused by methane that naturally accumulates in mines to the point where it creates explosive mixtures with air. These mixtures are most likely to form in abandoned, unventilated areas that can be several kilometers long. Once formed, the mixtures may be accidentally ignited and burn quickly, thus releasing large amounts of energy and generating high pressures. To protect workers from possible methane explosions, abandoned areas are separated from active areas by concrete walls, or seals, meant to withstand the high pressures generated by explosions and prevent propagation of shock waves and flames into working areas. To ensure that seals are strong enough, they must be designed to withstand the maximum pressures that can be generated by explosions that could occur in coal mines. In the absence of large-scale test facilities where pressures could be measured, computational models capable of predicting details of gas explosions are the only option for determining explosion pressures. Our research team, consisting of scientist and engineers from the University of Maryland (UMD) and the Naval Research Laboratory (NRL), is one of the world's leading research groups in numerical simulation of combustion systems and ideally suited to developing and testing the computational models needed. The importance of such a predictive capability extends beyond protective seal design, and even beyond the coal-mine industry. The same computational technology can be instrumental in developing new devices that could prevent or mitigate explosion in the many industries where there is a risk of gas explosions.

Impact of the Research: We propose to develop the numerical technology needed to predict the development of methane-air explosions in coal mine environments, and then use this technology to analyze protective-seal designs. For example, computed explosion pressures will be compared with current MSHA requirement for seal design. This technology can also be used in conjunction with experiments to develop other devices for explosion prevention and mitigation, thus making coal mining safer and reducing the number of disasters. This capability could benefit all industries where there is the risk of gas explosions.

Objectives and Research Approach: The objectives are to: (1) develop models that predict the properties of explosions for both uniform and non-uniform methane-air mixtures in appropriate large-scale geometries, and (2) use these models to analyze the efficiency of passive blast attenuators by computing the propagation of flames, shocks, and detonation through piles of rock placed at some distance from the protective seal. This project addresses a computational technology gap that exists in coal-mine research by developing and calibrating models that can accurately compute pressures at seals for different explosions scenarios. Computed pressures will be compared with current MSHA criteria for seal design.