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Title: Study of the Impact of Macro-Seal Fractures on Seal Integrity

Organization: University of Kentucky

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Partnerships: MINOVA USA Inc, Virginia Tech, Primekss

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

Synopsis

Project Goal: In April 2008, the Mine Safety and Health Administration (MSHA) issued a final rule to reduce the likelihood of seal failures and minimize the risk of explosion in abandoned areas of underground coal mines. The rule dictates different aspects of mine seals such as design, strength, construction, maintenance, repair, and other considerations associated. Commonly, materials used for the construction of the mine seals are concrete (reinforced and unreinforced) and cementitious foams. In most of the MSHA approved mine seals under the final rule, the designers use numerical (finite elements FEM) or analytical (plug design formula) methods for the analysis. One fundamental assumption in the analysis of mine seals is that the seal materials (especially for those using concrete or pumpable materials) are continuous and homogeneous solids. In most of the cases, during the curing process of the seal mixture, the process generates an exothermic reaction (hydration). The hydration, in some cases, causes shrinkage of the mixture which could generate cracks, fissures, and fractures. To date, there is not a study to assess the effects of fractures (generated during the curing process or in any other stage) in the structural behavior of mine seals. The proposed research investigates, through testing and numerical modeling, the generation of macro fractures and their effects on the structural behavior of mine seals.

Research Approach: The proposed research focuses on investigating the generation and effects of macro fractures on mine seal structural behavior and integrity. The fractures of concern are those fractures generated during the curing of the cementitious materials used for seal construction. The project includes the following objectives by phases:

Objective I – Mine seals inventory and fracture generation assessment

- To inventory and analyze, according to the MSHA database and other available data, the different mine seal designs approved and in use in industry,
- To construct representative samples of mine seals to collect information relevant to fracture generation during the curing process (heat, strains) combined with available MSHA results,
- To identify and assess the characteristics and properties of the macro fractures generated during the curing process (location, geometry).

Objective II – Structural and integrity assessment of the effects of fractures on mine seals

- To subject, mine seal samples to scaled methane and coal dust explosion testing,
- To perform a parametric study using numerical modeling, considering fractures.

Objective III – Proposal for alternative materials solutions

- To propose to the Alpha Foundation alternative materials or additives for mine seal construction.

Expected Outcome: There are several outcomes expected from this research. The following list includes the most important:

- Analysis of MSHA database regarding mine seals, Trend or relationship between curing parameters (heat, strains) and fracture generation initiation and density,
- Characteristics of macro fractures generated during curing (geometry, length, and aperture),
- Static and dynamic material properties used for mine seals,
- Results of scaled explosive tests (methane explosions) on the seals,
- Numerical methodology for the analysis of mine seals,
- Parametric relationships between mine seal integrity and macro fractures generated by curing or other processes such as stress conditions change.