Zipf, Richard K. (Karl) (CDC/NIOSH/PRL)

From: Grayson, Larry R. (Rolla) (CDC umr.edu)
Sent: Sunday, March 11, 2007 8:55 PM
To: Zipf, Richard K. (Karl) (CDC/NIOSH/PRL)
Subject: Comments on Explosion Pressure Design Criteria for New Seals in U.S. Coal Mines

Importance: High

Karl,

Thanks for the time extension. My comments follow.

First I would like to compliment NIOSH researchers for the very detailed analyses provided to reach the recommendations set forth in the study. The approach in searching the literature, interacting with foreign researchers, and working with the non-mining experts reflects sincerity in pursing the charge and in protecting the lives of miners. Generally I find the study enlightening scientifically and conservative in its approach to designing seals that will protect miners. My specific comments on the report follow.

In the discussion of seals and ventilation systems in underground coal mining (§ 1.2), one additional important reason for the transition from bleeder ventilation to sealing of abandoned areas was the difficulty of managing bleeder system ventilation temporally. Also bleeder entries were very difficult to maintain in passable condition over time, and the inability to inspect them in the entirety became problematic or even impossible.

In § 1.3A it would be helpful to the reader if 'outer gate entries' and 'inner gate entries' were defined before using the terms, or at least indicated in Figure 2A. The use is not clear in Figure 2A, especially when considering the statement that "inner entries may remain open for three to four kilometers or more in larger mines." Also in this section, in addition to judicious placement of the seals, it could be noted that operators certainly could design pillars surrounding the proposed locations for seals to be much large and more stable.

Similarly, a more clear definition of 'completely confined' and 'partially confined' would be useful. The terms are linked with the degree of venting, and knowing the level of venting that characterizes a partially confined condition would be useful to know.

The report does a good job in describing the inability to estimate accurately the level of methane and oxygen in many locations in a sealed area. In § 1.4, in paragraph one and/or two, I believe it is important to note that at least 10% oxygen is necessary for an explosion to occur, even though methane may be in its explosive range and an ignition source exits. This is the primary reason for making the sealed atmosphere inert.

Also in § 1.4, I do believe that the existence of an explosive methane-air mixture in the entire length of a sealed area, as shown in Figure 3A, is very conservative, and would have a low probability of occurrence; however, I certainly could not rule out the possibility of it occurring in a particular sealed area. I do believe further research, as discussed in the report, will eventually reveal an estimate of the probability for such occurrences, but not for a long time. This is an important consideration for potential revision of recommendations at a later date.

Concerning the discussion of the scenario presented in Figure 3C, often only immediate-roof falls during retreat mining when large barrier pillars are left in place, as shown. In essence the gob is not 'tight' but rather very open and thus would allow extensive venting. If, on the other hand, the barrier pillars were mined, as many mines do, then a fairly 'tight' gob would form regularly after the first fall on the panel occurs. These conditions would lead to variations on the scenarios presented in Figure 3.

In § 2.2, it would be helpful if a brief description was provided of the conditions of the United Kingdom and German full-scale tests. A discussion of the key parameters that influence explosions (volume of sealed area, run-up distance, degree of filling with an explosive mix, the degree of confinement or lack of it, and the degree of venting) would give the reader much greater understanding of the test results, and the ability to compare them with the U.S. results (USBM and NIOSH).

I am not sure what the stoichiometric requirement for oxygen is in relation to 10% methane. If a sealed area is depleted of oxygen, does the explosion become fuel rich at a certain level of oxygen (above 10%)? This would be useful to cite in the report, and may figure into the calculations of realistic estimations for an explosion when continuous sampling is done in the future.

In § 4.2, upon scrutiny of Figure 12, I don't agree with the statement that "For these small volume gas explosions, experiment and model compare well." In addition to offset of arrival times, which was noted, the pressure peaks for the three scenarios are significantly different at 12 psi (measured) vs. 6.7 psi (-44.2%) vs. 10 psi (-16.7%) for the 32.9-m test and two models, respectively, and 7.2 psi (measured) vs. 4.2 psi (-41.7%) vs. 6 psi (-16.7%) for the 160.3-m test and two models, respectively. Although modeling has provided some useful insights into ballpark numbers for explosion pressures, it is a reach to state, "In summary, despite the offset in timing, the gas explosion models reproduced the measured experimental data well." The next section, § 4.3, begins with the statement "Having calibrated the models successfully ..." which is also a reach in conclusion from the data presented. It is certainly okay to acknowledge the pitfalls of the models versus experimental results, and still use the models to gain insight into larger explosions, but the possible errors in estimates should be noted.

I would reiterate in § 4.3, in the next to last paragraph, that NIOSH does plan experiments in larger volume explosions in out years. However, in the interim the best means for protecting miners now must be based on existing analyses from all sources, including this report.

Regarding Figure 15, I note large variabilities in modeling results for a given length of explosion, in particular around 160 m, 230 m, and 300 m. I didn't see any explanation of why this occurred when only modeling was done. This should be explained in § 4.3 where Figure 15 is discussed, so that the reader can understand the variation in pressure better. The range of pressures for each of the three lengths noted are quite large; specifically for 160 m, an overall range of approximately 390 psi is noted, considering both AutoReaGas and FLACS results, and a range of approximately 240 psi is noted considering only AutoReaGas. The variability should be explained for the other two lengths of explosion, too.

Regarding Figure 18, the relationship may not be linear, as suggested. No best fit regression line was calculated, and looking at the plotted data, there is quite a gap in available data between 30 m and 60 m. If the coefficient of determination for a linear regression is above approximately 0.60, then maybe this could be stated as a linear relationship.

Section 5 is largely founded on the results from section 4, and thus some of the above statements, if addressed, may influence the bottom-line numbers adopted in Section 5. I don't believe that adjustments would be large though. With this said, in the first paragraph, I believe the researchers correctly stated that "The large volume gas explosion models hinted at the much larger explosion pressures that can develop ...." And this is the key point, regardless of whether the number adopted is 600 psi instead of 640 psi, or even 550 psi. Either way, it will be a high pressure level.

Some of the statements in Section 5 are confusing, particularly concerning the level of venting. Most of us accept that abandoned areas 'breathe', which means that there is a level of leakage in and out of the sealed area depending on the barometric pressure. It would thus be very useful if terms such as 'with no venting possibility', 'partial venting', and 'complete venting' were defined. The same goes for 'completely confined', 'mostly confined', and 'partially confined'.

In § 5e and § 5f, I don't understand how 33 ft and 15 ft were selected. In contrast, I completely understand how 165 ft was determined. I read the report over a second time to try to determine the rationale. Please explain it so that all will know clearly how these distances were obtained. It would also be helpful to know how 40% was selected as the critical percent of the sealed area volume in determining scenarios.

Larry

R. Larry Grayson, Ph.D., P.E.

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From: Grayson, Larry R.
Sent: Thu 3/8/2007 9:31 AM
To: 'Zipf, Richard K. (Karl) (CDC/NIOSH/PRL)'
Subject: RE: Draft seals report

Thanks, Karl.

Larry

-----Original Message-----
From: Zipf, Richard K. (Karl) (CDC/NIOSH/PRL) [mailto:rbz3@cdc.gov]
Sent: Wednesday, March 07, 2007 10:35 AM
To: Grayson, Larry R.
Subject: RE: Draft seals report

Larry,
Nice seeing you in Denver last week.
Comments next week are fine.
I really look forward to your thoughts on this sensitive issue.
All the best,
Karl

-----Original Message-----
From: Grayson, Larry R. (Rolla) (CDC umr.edu)
Sent: Tuesday, March 06, 2007 11:07 AM
To: Zipf, Richard K. (Karl) (CDC/NIOSH/PRL)
Cc: Grayson, Larry R. (Rolla) (CDC umr.edu)
Subject: RE: Draft seals report

Karl,

I cannot read the seal document over until this weekend - too much happening on rescue chambers in WV for me now. Can you accept my comments by Monday morning?

Larry

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Mining website: http://campus.umr.edu/mining/ -----Original Message-----
From: Grayson, Larry R.
Sent: Friday, February 09, 2007 12:34 PM
To: 'Zipf, Richard K. (Karl) (CDC/NIOSH/PRL)'
Subject: RE: Draft seals report

Thanks for sending this document for me to digest, Karl. I'll read it intently, and then get back to you with my thoughts.

Larry

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-----Original Message-----
From: Zipf, Richard K. (Karl) (CDC/NIOSH/PRL) [mailto:rbz3@cdc.gov]
Sent: Friday, February 09, 2007 12:29 PM
To: Grayson, Larry R.
Subject: Draft seals report

Dear Larry,

I hope all is well with you in Rolla. Lately I've been busy developing this report on seals that may generate some controversy.

Attached is a copy of the NIOSH draft report entitled, "Explosion Pressure Design Criteria for New Seals in U.S. Coal Mines." I thought you might be interested in having a draft copy.

This report addresses two critical issues: 1) what explosion pressures can develop during an explosion within a sealed area?, and 2) what are appropriate design criteria for seals that will withstand these pressures?

Based on fundamental knowledge of explosion chemistry and physics and knowledge about sealed areas in mines, NIOSH engineers recommend a three-tiered explosion pressure design criteria for seals in coal mines.

1) For unmonitored seals where there is a possibility of methane-air detonation behind the seal, the recommended design pulse rises to 4.4 MPa (640 psi) and then falls to the 800 kPa (120 psi) constant volume explosion overpressure.

2) For unmonitored seals with little likelihood of detonation, a less severe design pulse that simply rises to the 800 kPa (120 psi) constant volume explosion overpressure, but without the initial spike, may be employed.

3) For monitored seals where the amount of potentially explosive methane-air is strictly limited and controlled, engineers can use a 345 kPa (50 psi) design pulse if monitoring can assure 1) that the maximum length of explosive mix behind a seal does not exceed 5 m (15 ft) and 2) that the volume of explosive mix does not exceed 40% of the total sealed volume.

Based on these explosion pressure loads, NIOSH engineers used a dynamic computer modeling program and other methods to determine minimum seal thickness to resist these explosion pressure loads. The analyses show that resisting the worst case 4.4 MPa (640 psi) design pulse is reasonable using modern materials. For example, a 6.1 m (20 ft) entry that is 1.5 m (60 in) high requires a 0.9 m (36 in) concrete seal, whereas a 2.4 m (96 in) high seam would require a 1.2 (48 in) concrete seal.

The report also provides an alternative to these worst-case scenarios, if the atmosphere behind the seals is monitored and inerted, as is done in many mines abroad. In that case, seals to withstand a pressure of 345 kPa (50 psi) may be adequate.

If you have any thoughts on the report, please let me know.

All the best,

Karl Zipf

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