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Technical Review
Explosion Pressure Design Criteria for Seals in U.S. Coal Mines

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1. CRITIQUE:

Page 15, paragraph 2
Figure 7: data is below theoretical curve because of incomplete fuel consumption

Page 17, equation for p_V
This equation is false.
Pressure density and velocity are independent variables throughout the flow field.
For steady flow: $h + V^2/2 = h_0 = stagnation\ enthalpy$
This leads to the following relation between p & V: $\gamma(\gamma-1)p + 0.5\rho V^2 = \rho h_0$ which is valid along an isentrope expanding from the stagnation condition
SOLUTION: this equation is true only at a shock front, so just say at a shock……..

Page 19, equation for reflected pressure
Correct, I checked it with Stanyukovich (1960) p. 373 eq. (47;9)

Page 19, last paragraph
Method used to calculate the 2,300 psi is questionable.

Page 21, paragraph 4
The explosion pressure does not obey the linear relation quoted here (see figure 6 of this report).

Page 25, paragraph 1
"gas explosion models reproduced the measured experimental data quite well"
I have a different assessment of the comparisons

	AutoRealGas Code
3 m	waveform poor
32 m	waveform good, peak is low by factor of 2
160 m	waveform poor, but gives an upper bounding curve
	FLACS Code
3 m	waveform good, TOA late by 0.3 sec (⇔100m)
32 m	waveform good, TOA late by 0.3 sec (⇔100m)
160 m	excellent waveform, TOA late by 0.3 sec (⇔100m)

Waveforms are qualitative similar to experimental data, but numerical models are missing the fundamental physical mechanism that controls the energy release process. Nevertheless, waveforms have about the right impulse, so for seal design they are OK.

Page 26, paragraph 2
"simple linear relationship exists between explosive mix length and peak pressure developed at the seal".
The relationship is not linear, perhaps quadratic

Page 27, paragraph 6
"For a partially confined volume.... 50 psi..."
Please justify, I do not follow how you got this number

Page 28, paragraphs labeled (4), (5) & (6)
...50 psi... Figure 22
Please justify, I do not follow how you linked this scenario with Figure 22

Page 29, paragraph 5
You consider only methane-air explosions. What about methane/coal dust/air explosions? Do you recommended waveforms (Figures 20, 21 & 22) bound these cases also?

Page 30, paragraph 6
"approximate this pulse with a 2 MPa (300 psi) static load" The structural response depends on the impulse $I_+ = \int_0^\tau p(t)dt$ coupled into the system during the structural response time τ, so an equivalent pressure would be $\bar{p} = I_+ / \tau$. I doubt that this equals 300 psi.

Pages 31-35, structural response
No comment, as this is not my specialty.

2. ASSESSMENT

- This report represents a professional engineering assessment of the seal design criteria; it seems to do a better job than previous reports
- **Executive Summary**: is quite valuable; it tells you where we are going
- **Introduction**: gives a good introduction to the subject, quite useful to those not knowledgeable in this field. Survey of recent coal mine explosion accidents puts things in perspective, and sets the stage for the remainder of the report.
- **Section 2:** gives a very valuable review of existing seal design criteria throughout the world, and their scientific basis (or lack there of),
- **Section 3:** gives a good over-view of pertinent explosion chemistry and physics related to this problem. **FACTS 1-4** give a good emphasis of the key numbers of the problem. The historical review of measured mine explosion pressures (Section 3.8) builds a strong case that the current "20 psi criteria" is not credible. Section 3.9 (mis-labeled as 3.8) gives a good summary of the problem parameters that affect the explosion severity.
- **Section 4:** applies the current state-of-the-art commercial codes (AutoRealGas & FLACS) to the seal design problem. Although their models are inadequate to perform a "First Principles direct numerical simulation" (i.e., without turbulence modeling, etc...)

of the entire problem from inflammation to detonation, they are certainly technically adequate for predicting pressure waveforms for engineering studies of seal designs.

- **Section 5:** delineates explosion scenarios and the corresponding waveforms appropriate to each case. Very valuable.
- **Section 7:** recommends two approaches for seal design construction; very valuable. It also recommends additional research to further refine potential explosion environments.

3. RECOMMENDATIONS

Methane/coal dust/air explosions can have much more complex energy release modes (e.g. double detonations, etc) which lead to correspondingly more complex waveforms than those considered so far. This will involve stratified fuel-air systems. Such systems are relatively un-studied, and thus are an appropriate subject of future NIOSH research.