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

**From:** MikeWieland@icdus.com
**Sent:** Tuesday, April 24, 2007 11:01 PM
**To:** Zipf, Richard K. (Karl) (CDC/NIOSH/PRL)
**Subject:** Two Pages Wanted
**Attachments:** RKZipfMthnGsXplosnTwo.doc

Hi Karl, Take a look, hopefully nothing is untoward. Got the other trace in, took out the irascible(s), I hope, Though anybody born with 75 miles of Lebanon bologna factory makes stuff up. Talk to you soon, Mike

Remarks and Computations Related to NIOSH Seals Report

Mike Wieland, UNCERTAINTY INK

Revision Date, April 24, 2007

The draft report, *Explosion Pressure Design Criteria for New Seals in U.S. Coal Mines by R.K. Zipf, M.J. Sapko and J.F. Brune,* was released in 2007 for outside comments. This report represents considerable innovation that rests upon relevant well-supported scientific findings. Upon recognizing the complex and transitory nature of the phenomena involved, none of those findings differ significantly from work-principle and other theoretical model results, for reaction-gas mixtures close to stoichiometry. The overpressure 4.4 MPa design criterion relates to the upper-limit of the total (absolute) normally reflected detonation pressure, 4.55 MPa for methane/air. The second design overpressure criterion of 0.80 MPa is a logical round-off to NIOSH closed bomb-calorimeter or the upper-limit work-principle results, 0.88 MPa. The chosen criteria are justifiable, considering how hard it is to design retention structures for such harsh circumstances.

The experimental work encompasses nature's complexity or non-ideality that is not readily accounted for with theoretical restrictions. The modeling utilized contains no transfer coefficient effects, tends to over-estimate and fails to recognize the role of reaction extinction, unlike the test data. The unrealistic non-zero information in the wide-tails of the graphical curves outside the journal reported extinction limits should be disregarded, though near stoichiometry, the theoretical results only slightly overestimate results found experimentally. Four different theoretical circumstances were compared graphically, some of which were resolved with fewer points in the seals report: the work-principle explosion (refer to recent ISEE publications and references therein), the constant volume explosion, the Zeldovich von-Neumann Doering (ZND) detonation at the Chapman Jouguet (CJ) condition and the 'rigid-wall' normally reflected wave for that circumstance. The four maximum pressures, which represent the highest point resolved in constructing the graphical traces, occur slightly to the rich side of their stoichiometric methane concentration.

While the detonation modeling includes kinetic energy and is post run-up, the two explosion results are without relative motion and therefore ignore dynamic pressure. Wave-humping or the reality of impure methane or rough wall influences require the additional considerations that were noted in the report. Other naturally-occurring gases can occur in minor (though nontrivial) proportions, usually ethane or rarely propane. Worst-case near stoichiometry, these two reactant gases individually yield slightly higher explosion pressures than methane, so natural gas mixtures represent a worrisome prospect, not wholly (or readily) addressed. The second design criteria mentioned in the seals report therefore could underestimate some worst-case possibilities; the methane/air remains the logical typical guideline circumstance.

## TABULATED/GRAPHICAL RESULTS

Relevant explosions occur within journal reported methane extinction limits: 5 mol% to 15 mol%. Graphed work-principle Z-state (fireball) explosion results are denoted "XplosnWP". Graphed constant density explosion results are denoted "ConstRho". The ZND-CJ detonation results are denoted "DtontnCJ". The ZND-CJ detonation normally

reflected results for rigid wall with zero particle velocity are denoted "RflctNrml". [Normal pressure = 1 atmosphere ≡ 1 atm = 1.01325 bar = 0.101325 MPa = 101.325 kPa ≈ 14.7 psi, whereas 1 bar ≈ 14.5 psi. When compared to the report overpressure guidelines, it is necessary to subtract off unity form the relative (total/normal) pressures in the graph traces.] The highest resolved points in the graph traces were rounded-off when rendered in other units to a reduced number of significant figures:

Normally reflected detonation: high pt. 44.91 atm = 45.5 bar = 4.55 MPa;
ZND-CJ detonation: high pt. = 17.52 atm = 17.8 bar = 1.78 MPa;
Constant density: high pt. = 8.954 atm = 9.1 bar = 0.91 MPa;
Work-principle Z-state explosion: high pt. = 8.726 atm = 8.8 bar = 0.88 MPa.