

CFD Analysis of Blast Venting from a Magazine into a Chamber

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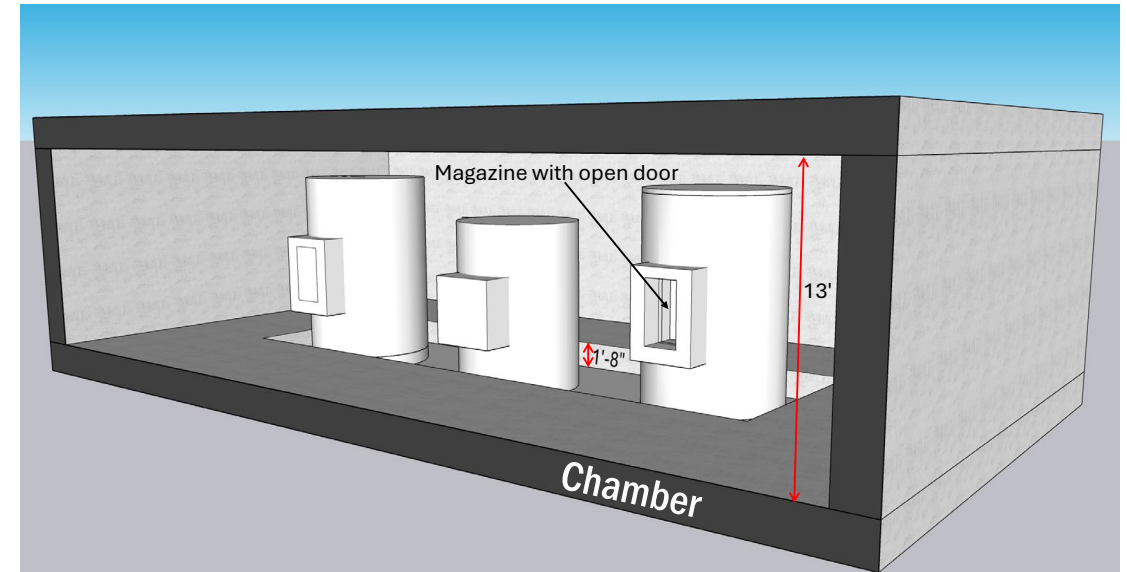
Problem Statement

► Scenario

- Magazines used to store explosives
- Magazine rated to contain the effects of an internal detonation
- But what if the door were open?
 - E.g., as explosives are being emplaced/removed

► Containment chamber

- R/C chamber within which magazines are placed
- How to estimate loads on this chamber?



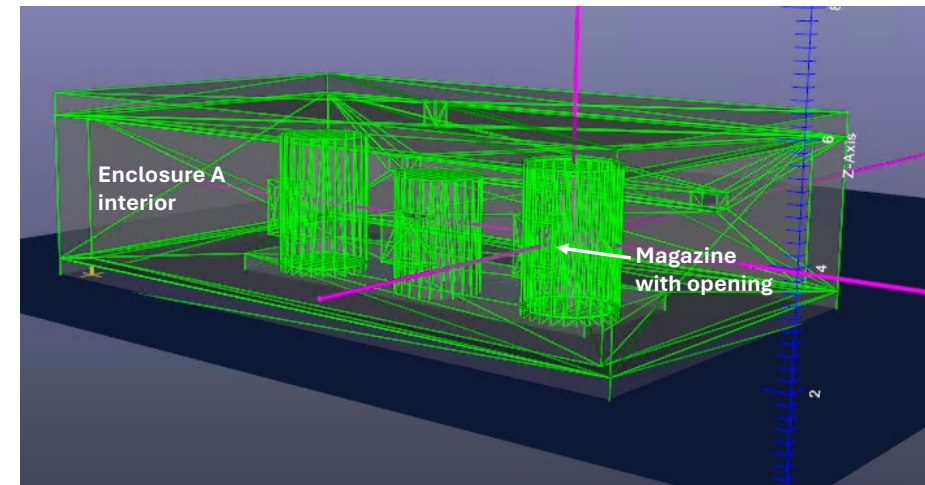
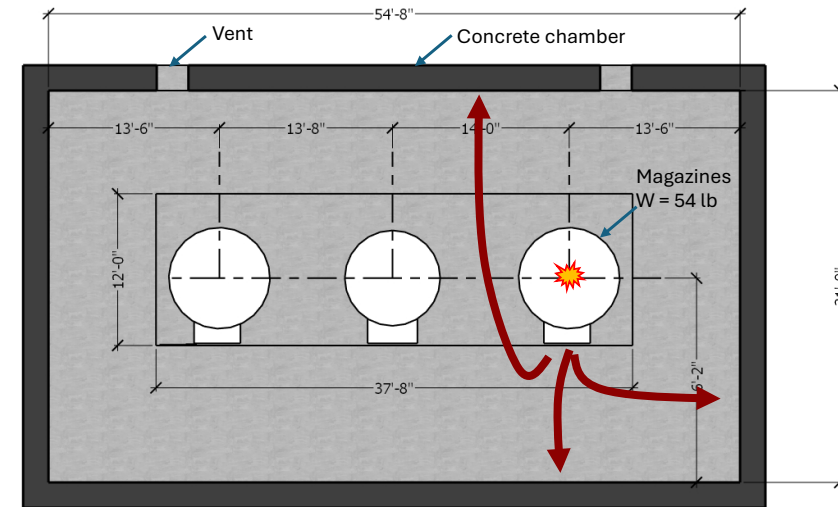
Analytical Approaches

► Traditional: UFC 3-340-02

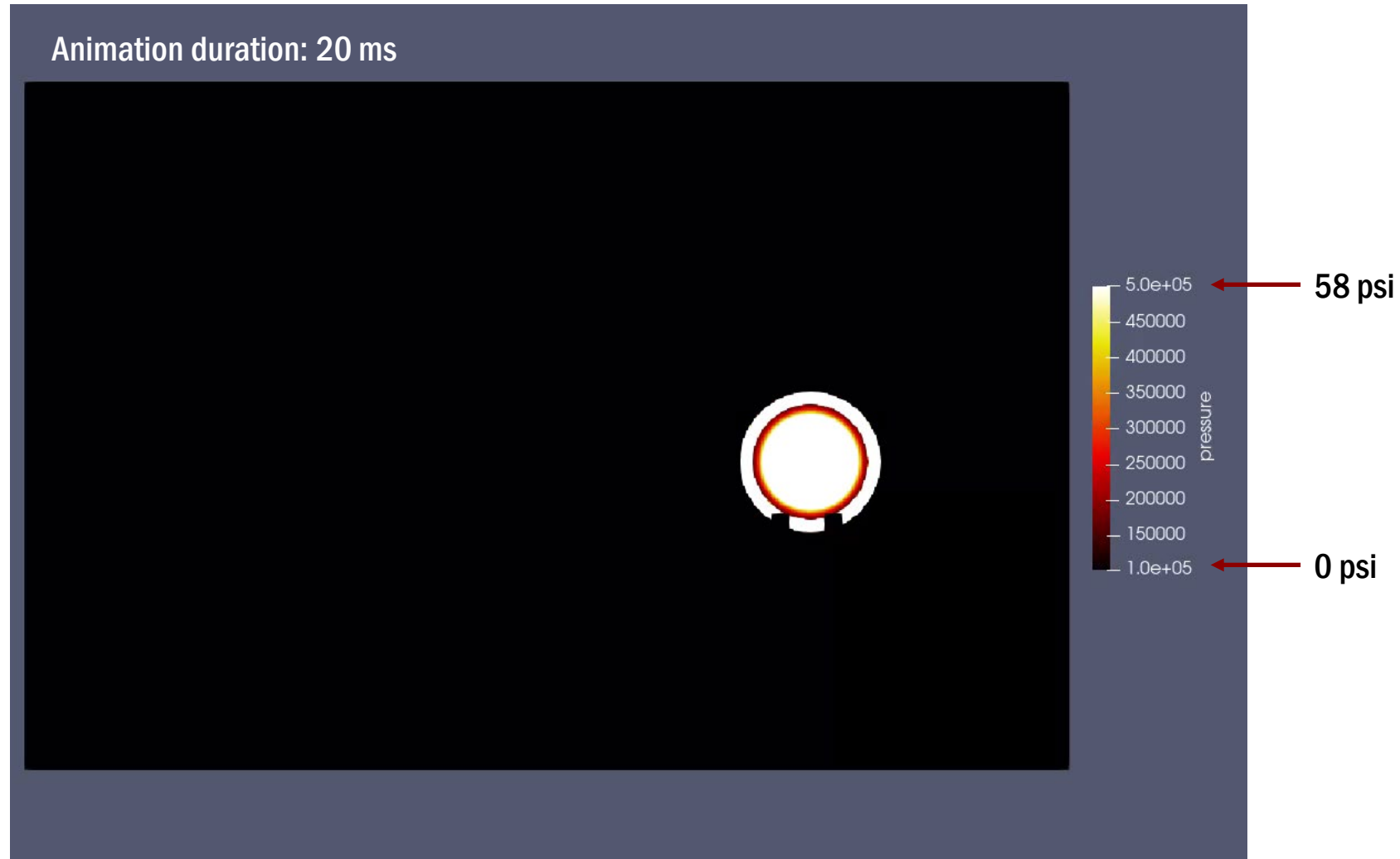
- Ignore magazine
- Calculate internal blast (shock and gas) using ConfinedBlast
 - Ignore magazine
- Or, use blast leakage curves

► Alternative

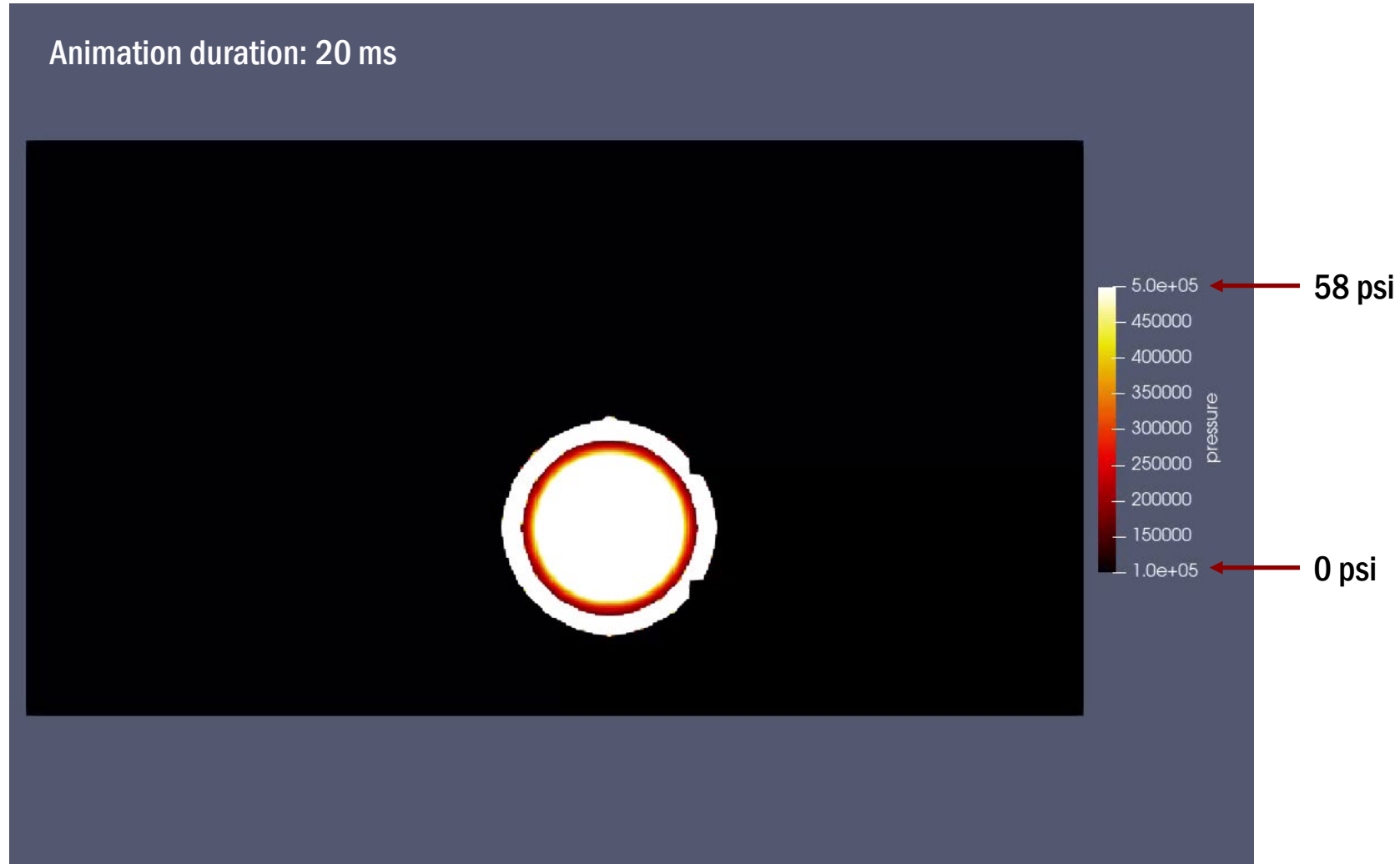
- CFD model in Viper::Blast
- Less conservative than engineering methods
- More physical



Viper Result: Plan View



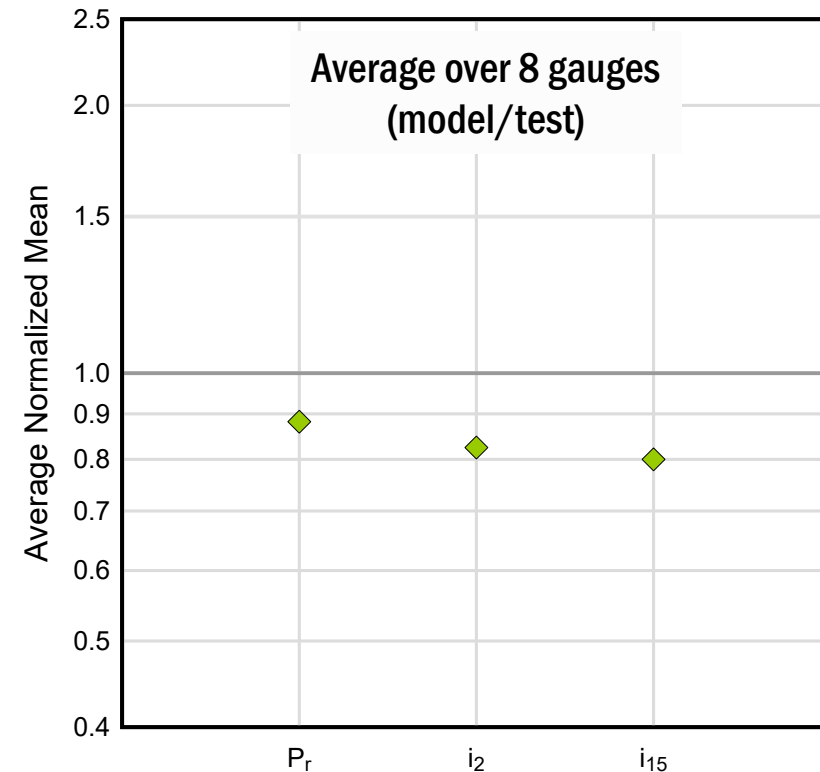
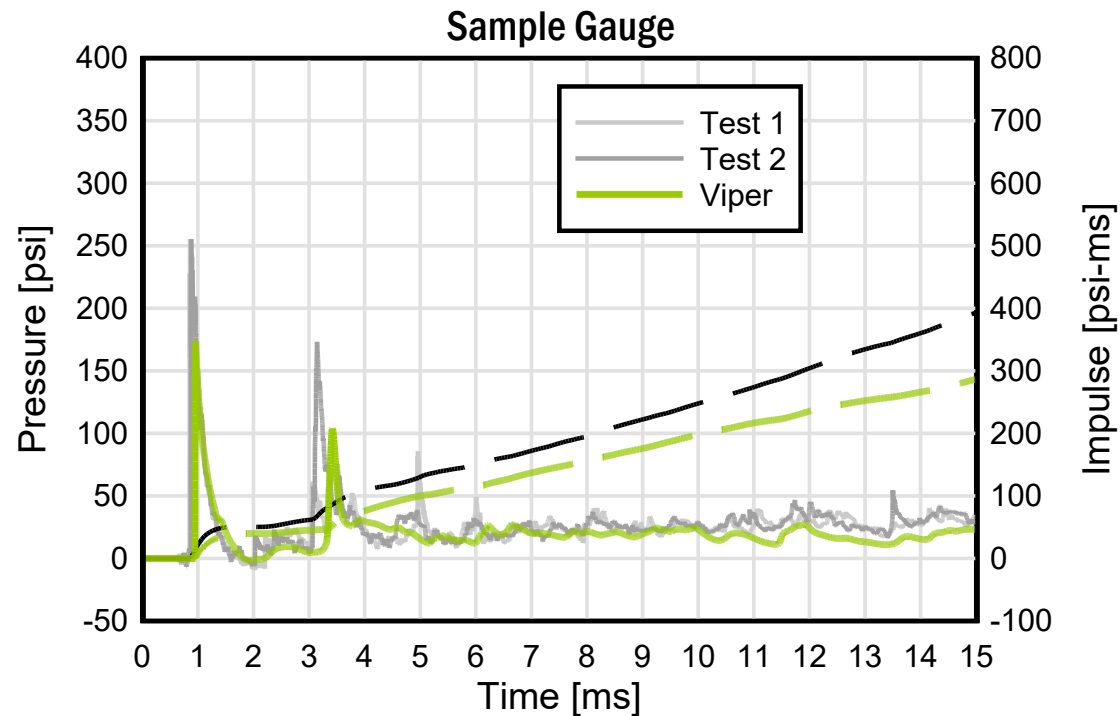
Viper Result: Elevation View



Viper Validation

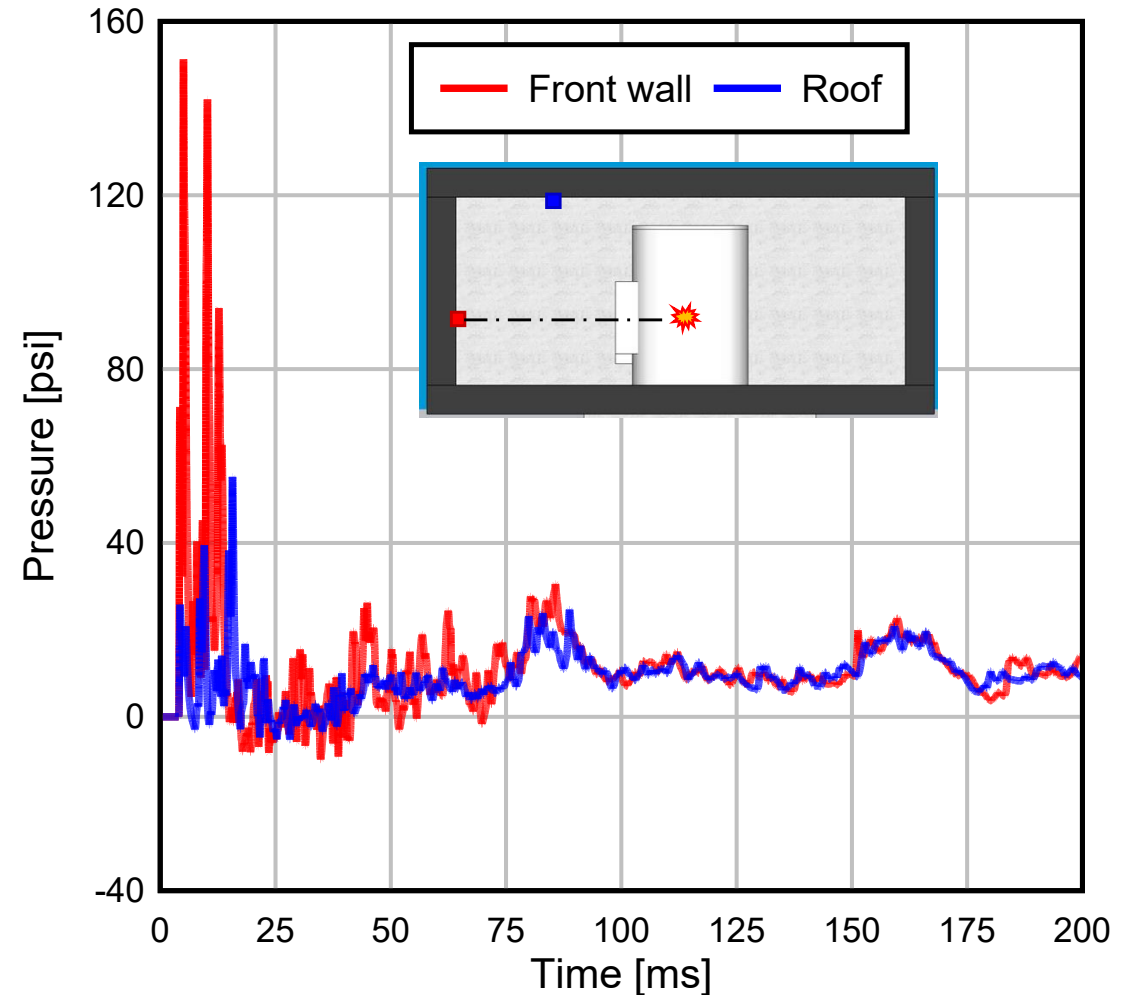
► Prior validation of Viper for internal detonations

- D. Bogosian, D. Powell, P. Lopez-Fernandez, D. Littrell, and M. Gonzalez, “Validation of Codes for Prediction of Internal Airblast,” ISIEMS 2024, Bonn



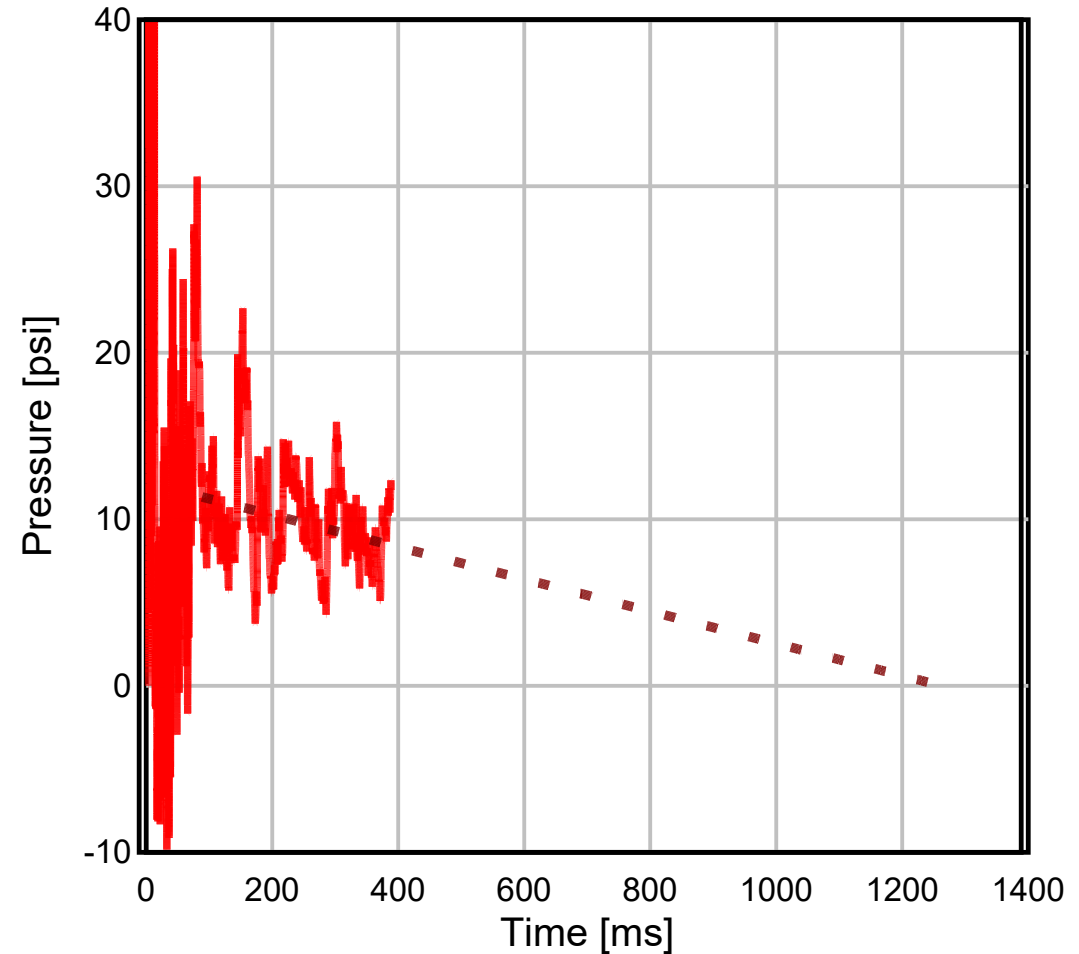
Viper Results

- ▶ **Significantly higher pressures on front wall than on roof**
 - Early-time differences
- ▶ **Everything after 25 ms dominated by gas**
 - Uniform in room



Extension of Viper Results

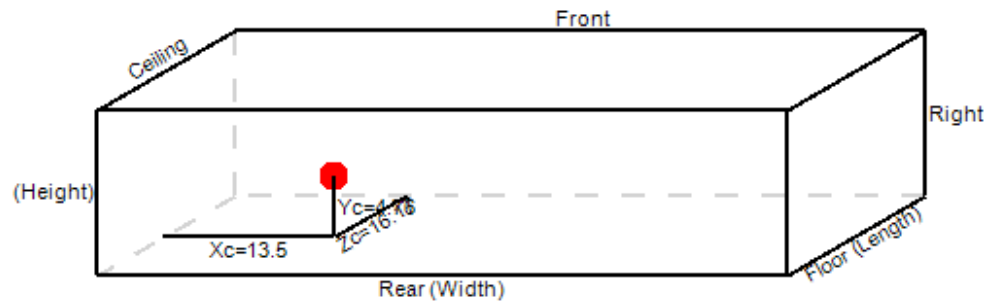
- ▶ Calculation ran to 400 ms
- ▶ Used linear extrapolation to estimate venting



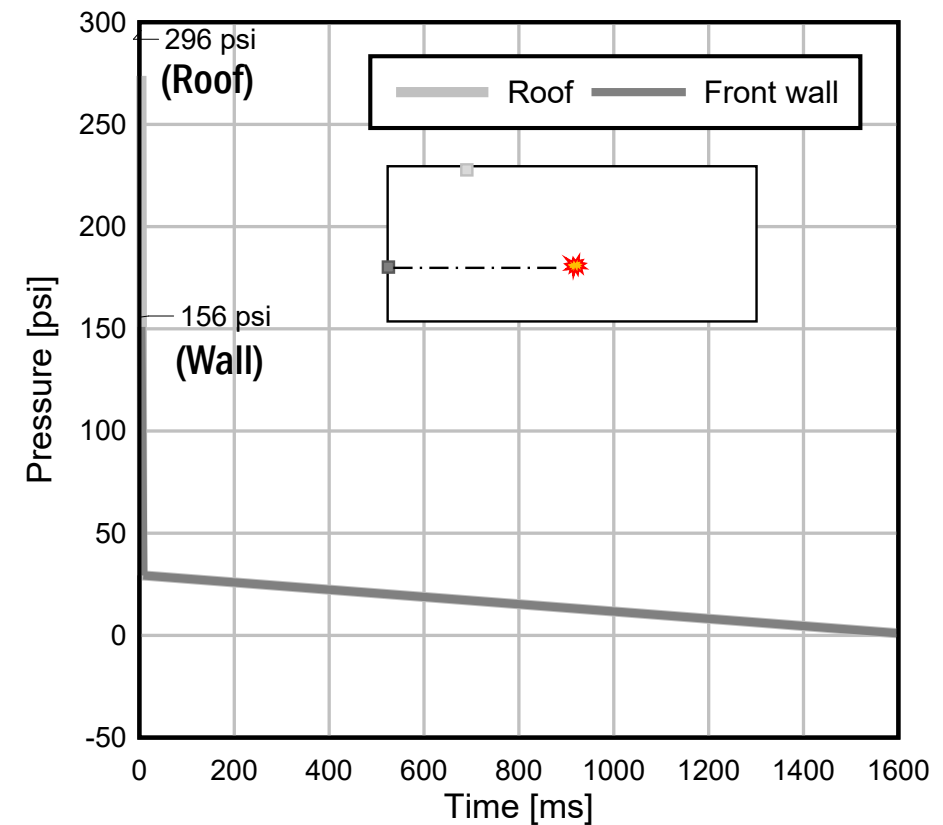
Engineering Method 1

► ConfinedBlast model

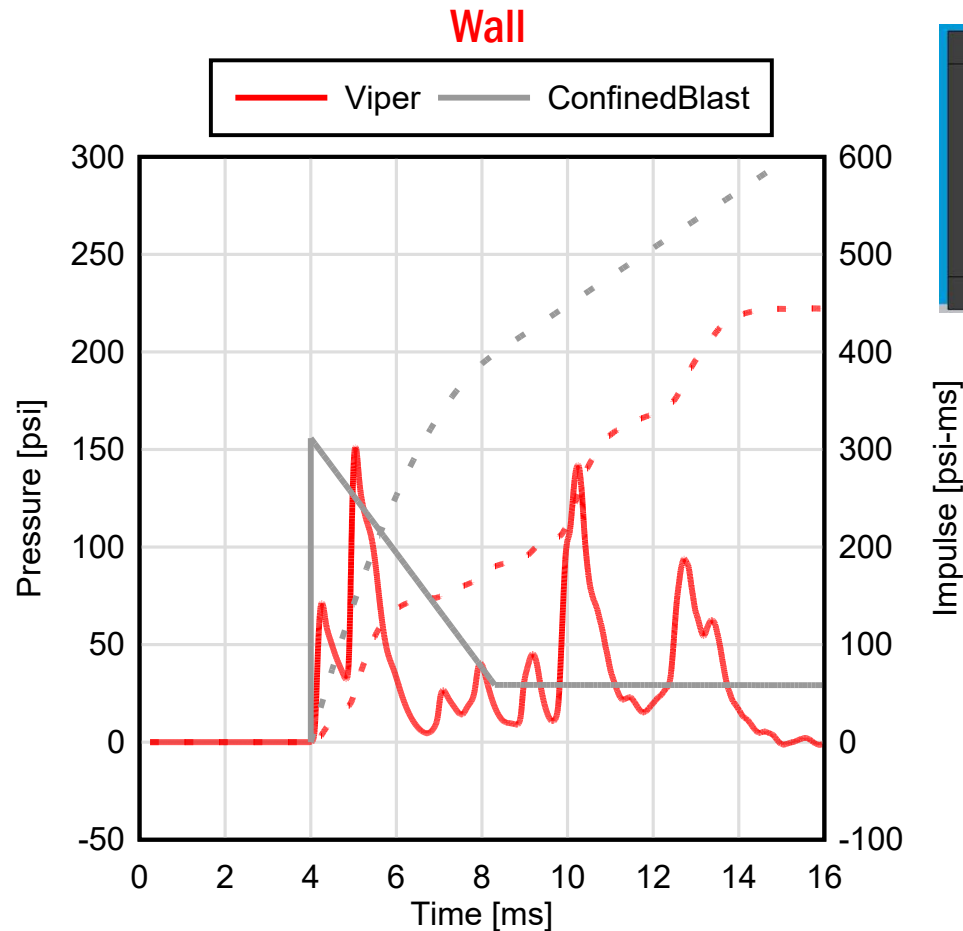
- Ignore presence of magazine
 - Conservative
- Use internal dimensions of chamber



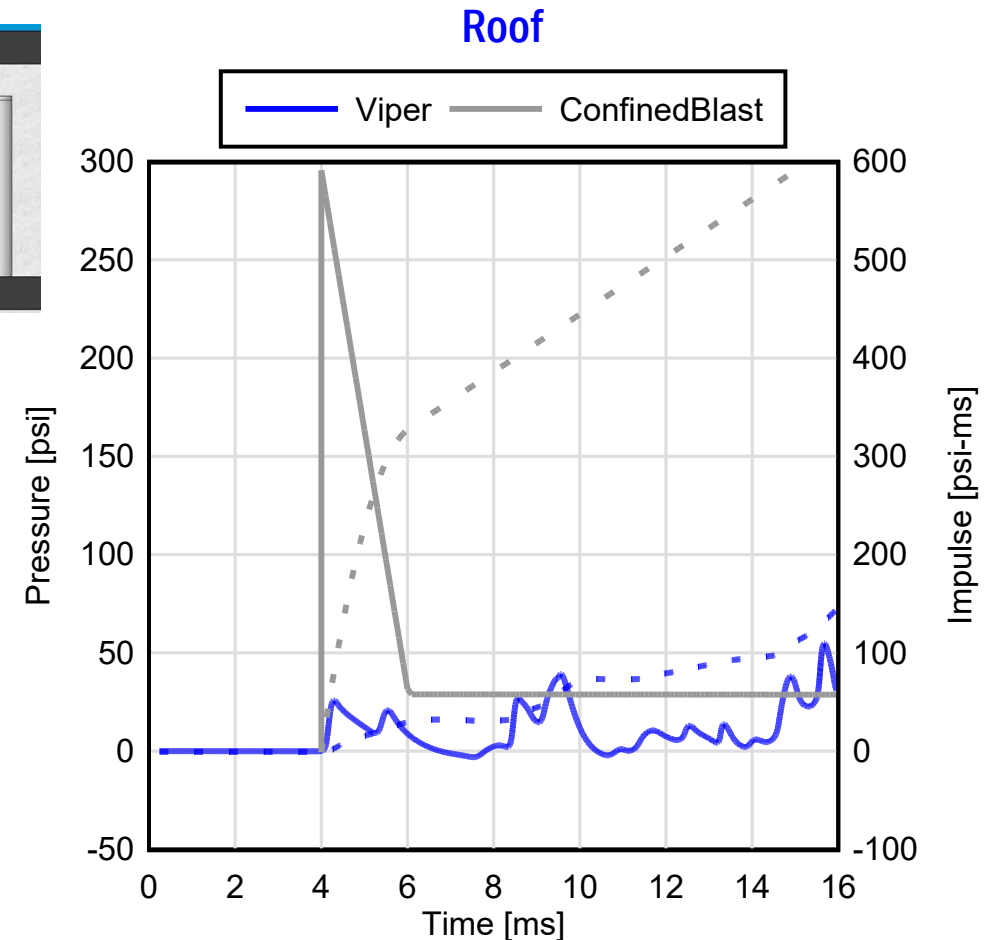
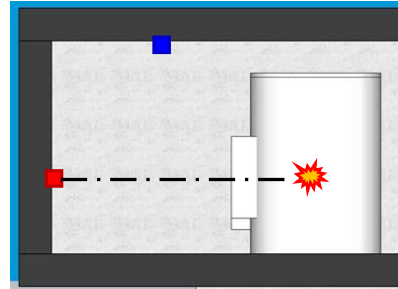
► Result



Shock Comparison



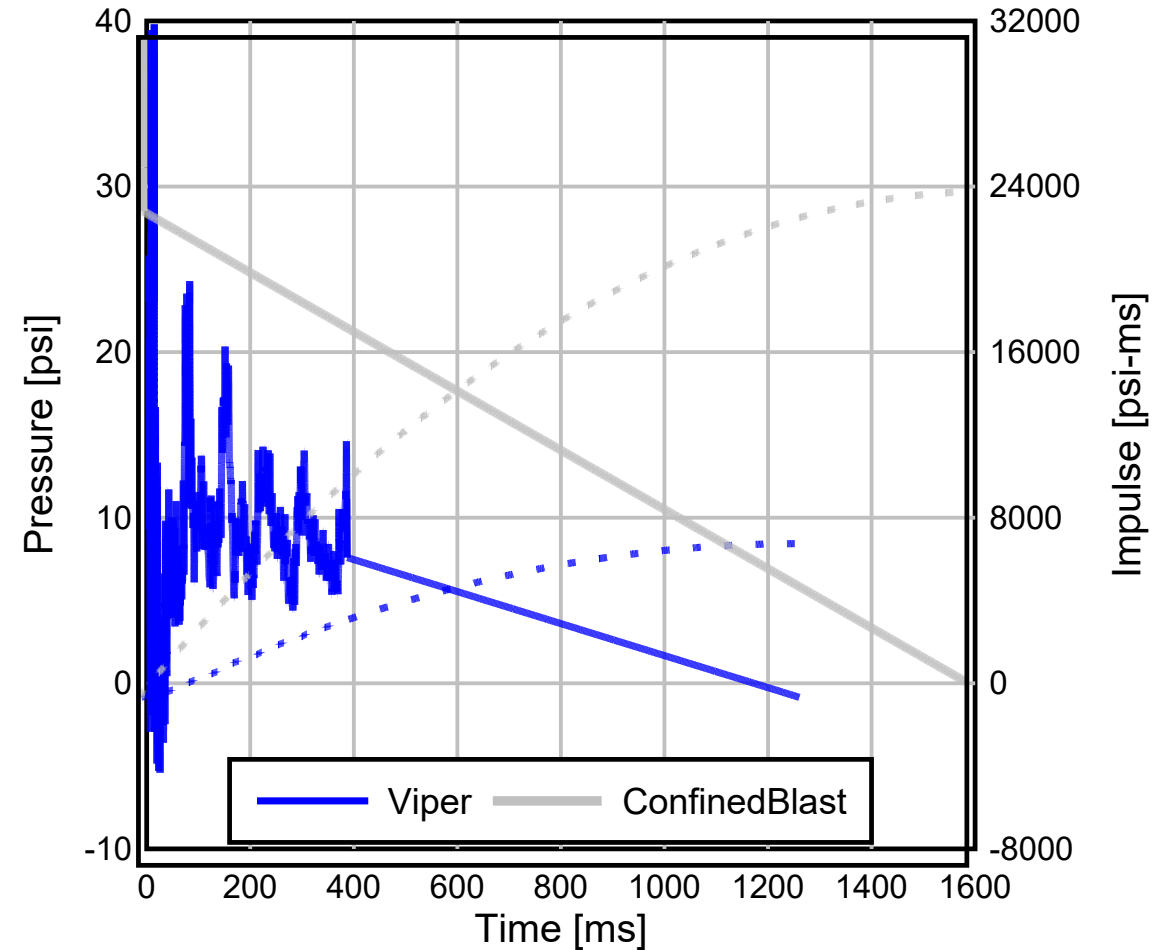
- Peak pressure quite good
- Early impulse not bad



- Peak pressure very poor
- Early impulse very poor

Gas Comparison

- ▶ **Very conservative**
 - Peak gas pressure high by factor $\sim 2+$
 - Total impulse high by factor ~ 3
- ▶ **Well-known “features” of FRANG**
 - Observed in earlier validation study (ISIEMS paper)
 - Also, Viper is likely a bit low



Impact on Design of Chamber

- ▶ Designed chamber to sustain Viper loads
- ▶ Selected reinforced concrete design parameters
 - 20-inch thick
 - #5 rebar, ea. way, ea. face
 - Same design for both wall and roof
- ▶ Then checked design vs. ConfinedBlast loads

- ▶ Consequence of loading methodology

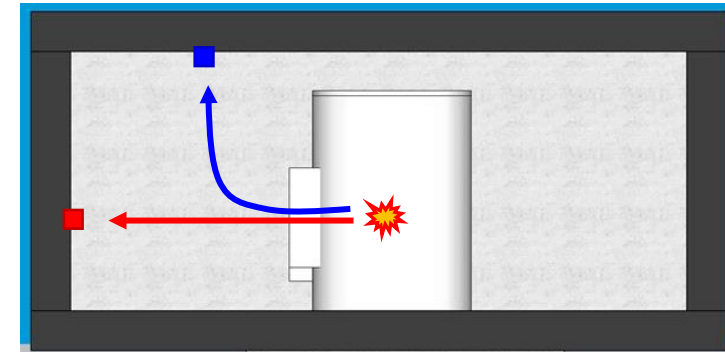
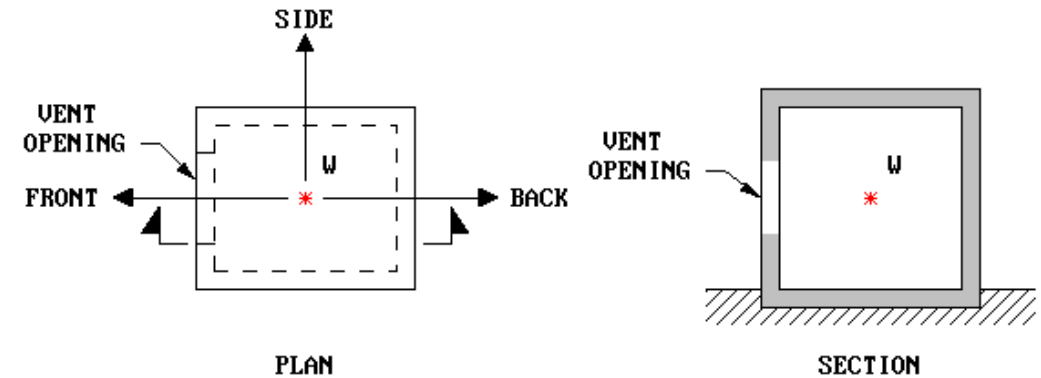
Component	Support Rotation [°]	
	Viper	ConfinedBlast
Wall	0.2	1.0
Roof	1.8	>>12 (<i>fail</i>)

- ▶ Roof design would have to be substantially heavier using ConfinedBlast loads

Engineering Method 2

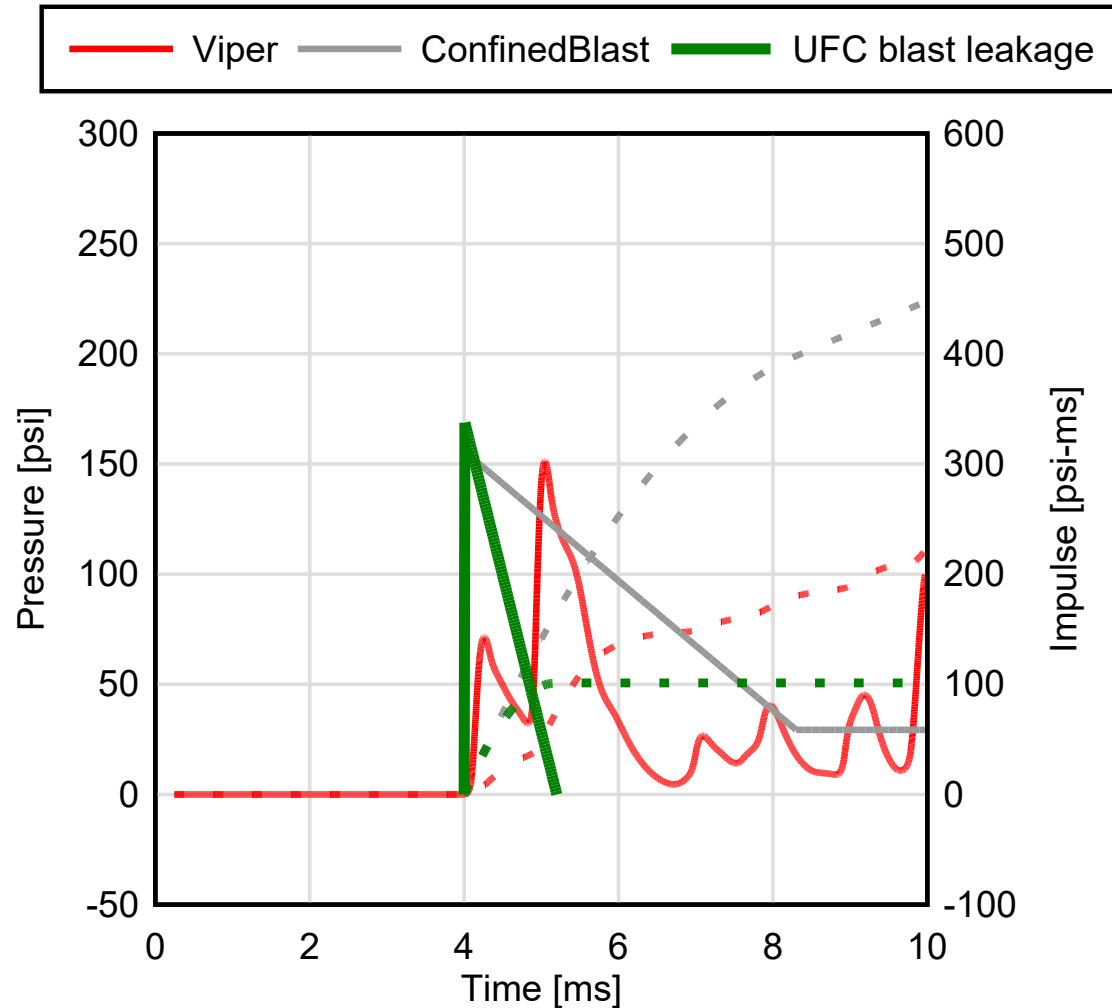
- What if we applied the blast leakage curves?
 - Magazine treated as a 4-walled cubicle with a wall vent
 - Calculate the incident pressure, impulse
 - Front wall: “front”
 - Roof: “side”
 - Apply reflection factors

Figure 2-186. Four wall cubicle vented through a wall and direction of blast wave propagation

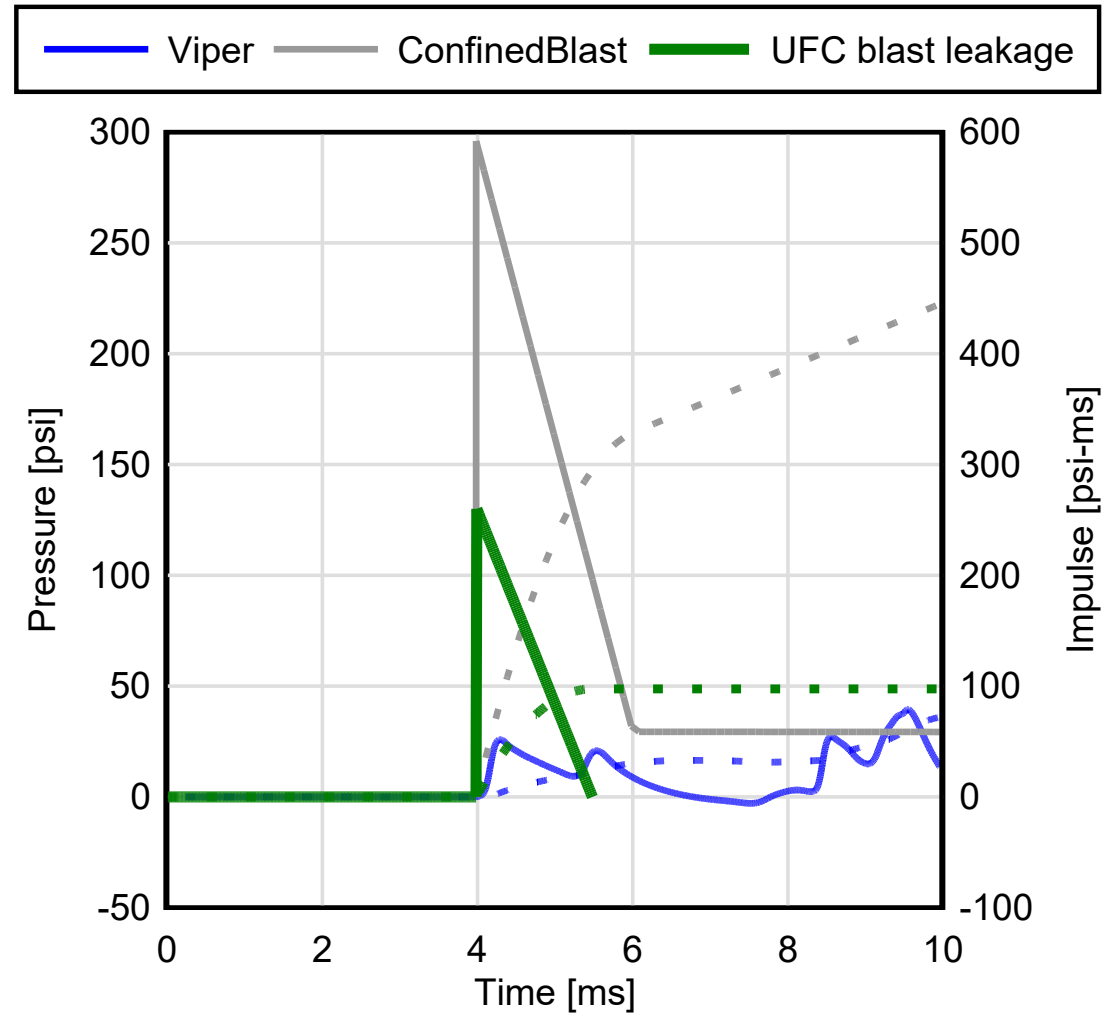


Blast Leakage Results

Wall



Roof



Conclusions

► ConfinedBlast

- Greatly overestimates gas pressure and total impulse
- Shock on wall reasonable
- Shock on roof greatly overestimated

► Blast leakage

- Shock on wall reasonable
- Shock on roof greatly overestimated
- Does not consider internal reflections
 - Non-conservative on early impulse

► High fidelity modeling

- Provides a more accurate design load, especially for shock
- Accounts for all significant physical features
- Less conservative
- More efficient wall and roof design
- Improvements to gas phase modeling would further improve realism