SAND2009-2296C

Processing German Tractor Rockets with Propellant in EDS

Brent Haroldsen
Matt Risenmay
Sandia National Laboratories
Warren Taylor
PMNSCM

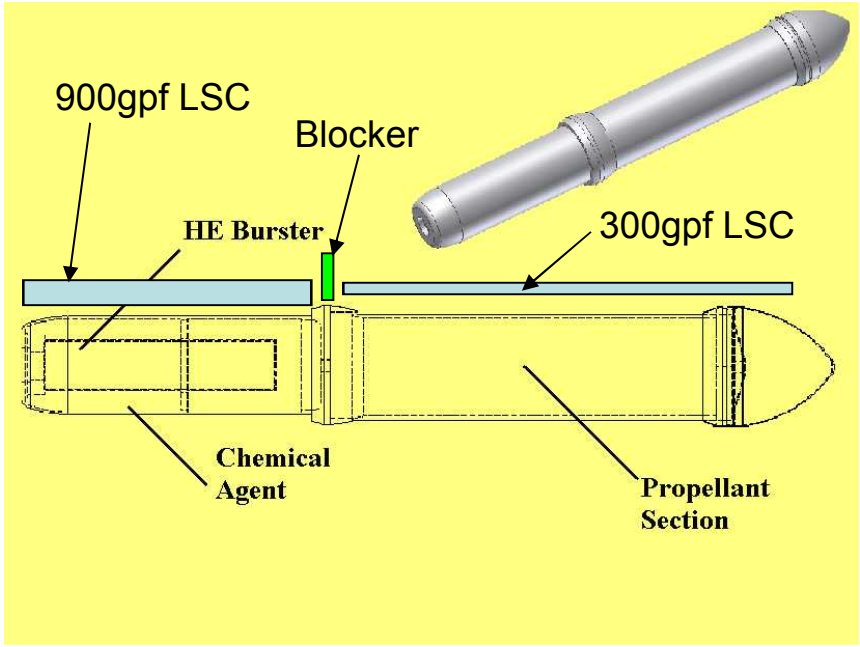
Sandia National Laboratories

Overview of the Problem

- 56 remaining GTR's at Pine Bluff have propellant in the motor
- The previous plan was to remove the rocket motors before processing the warheads in EDS
- That option is no longer acceptable
- PMNSCM wants to process the entire GTRs in EDS
- The total weight of energetic materials exceeds the approved rating of the EDS P2 vessels (2.18 kg TNT)
  - ~1410 grams of burster
  - ~5920 grams of propellant
  - ~270 grams of linear shaped charge

We Have Proposed a Multi-Tiered Safety Philosophy

- Configure shaped charges to open the motor without detonating the propellant
  - Planned operation will be within the currently approved limits
- Demonstrate total containment in the vessel even if the propellant detonates
  - Assume worst case, prompt detonation of all energetic materials
  - Vessel might be damaged, but the operation can be completed
- Ensure containment of agent in the environmental enclosure even if the vessel fails
  - Leak before burst

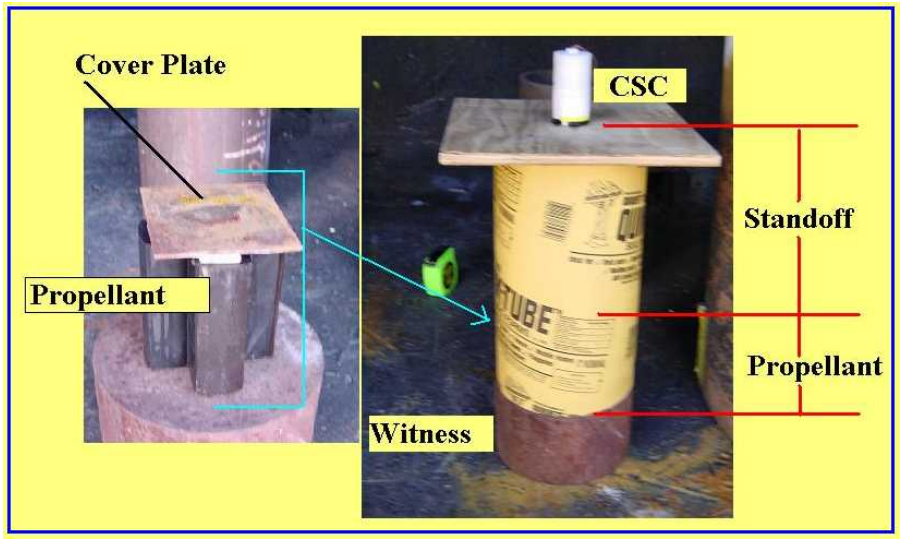


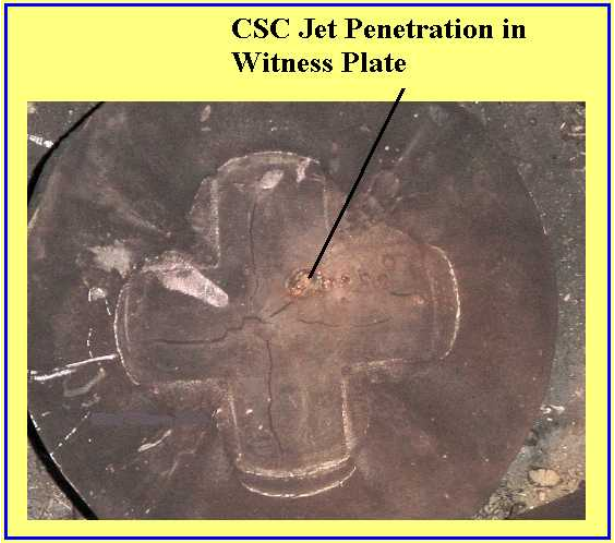
Sandia National Laboratories

V^2D Comparative Testing

- Literature and previous testing indicates V^2D threshold for detonation of JPN/DEGDN propellant is about 60mm^3/ms^2.
- No EDS LSC in use meets impact detonation requirements for a typical Double-Based Propellant

Copper LSC loading (grains per foot)	V (mm/μs)	D (mm)	V^2D ($mm^3/\mu s^2$)
150	3	1	9
300	3	2	18
600	3	3	27
900	3	3.5	31.5
1200	3	4	36

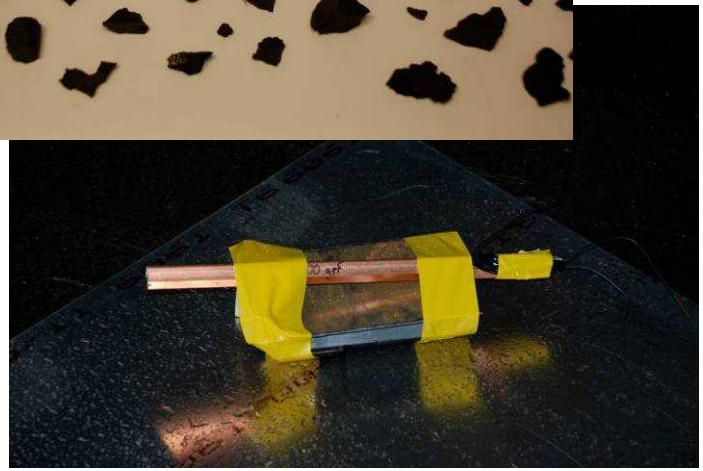




Sandia National Laboratories

LSC Testing

Testing of 600gpf LSC in simulated GTR configuration shows no detonation

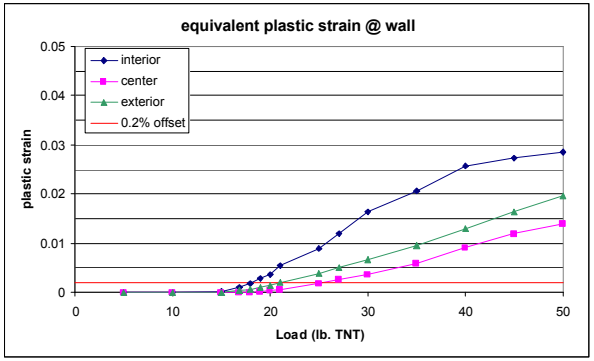


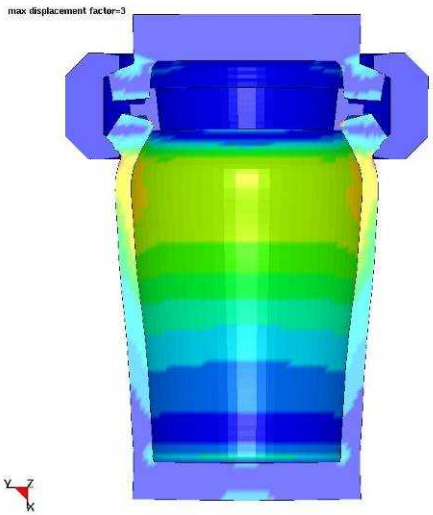
Testing shows no detonation for LSC loadings from 150 to 900gpf

Sandia National Laboratories

Containment of Worst Case Detonation

- Computer modeling
- ASME Code
- Explosive testing

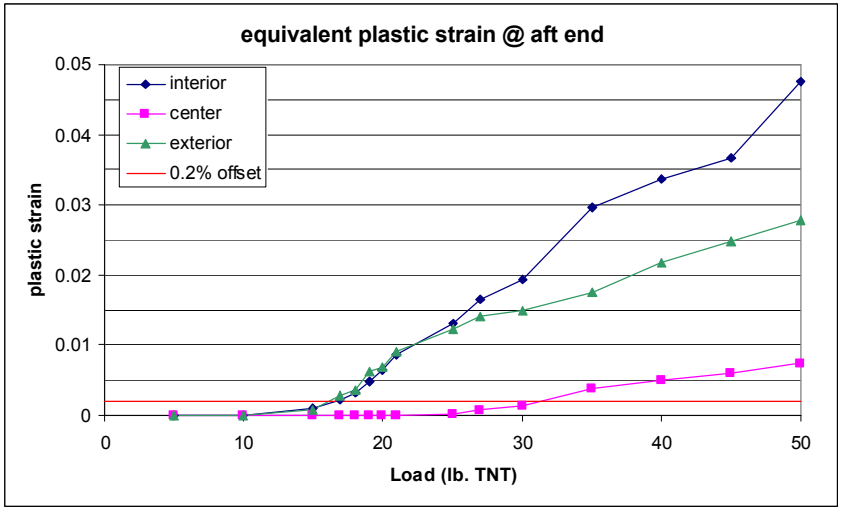


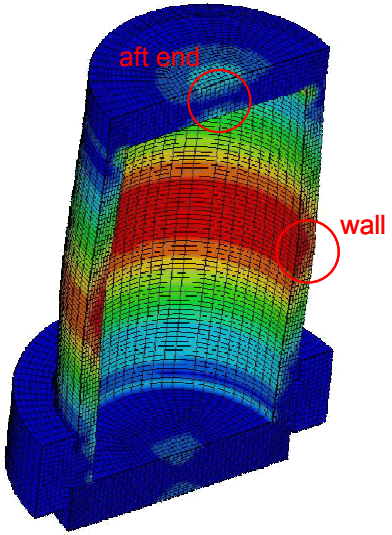


Sandia National Laboratories

ASME Rating for Single Use is 17.9 lbs TNT Equivalent

- For repeated use with hundreds of detonations, the rating will be limited by fatigue or cumulative distortion
  - These are not relevant for a single off-normal event
- The code case is based on protecting the asset
  - The task group is considering different criteria for applications where the vessel must protect safety, but need not be reusable



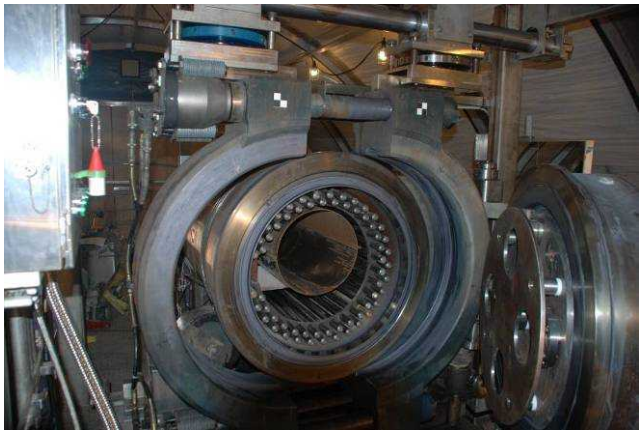


Sandia National Laboratories

Summary of Recent Explosive Tests

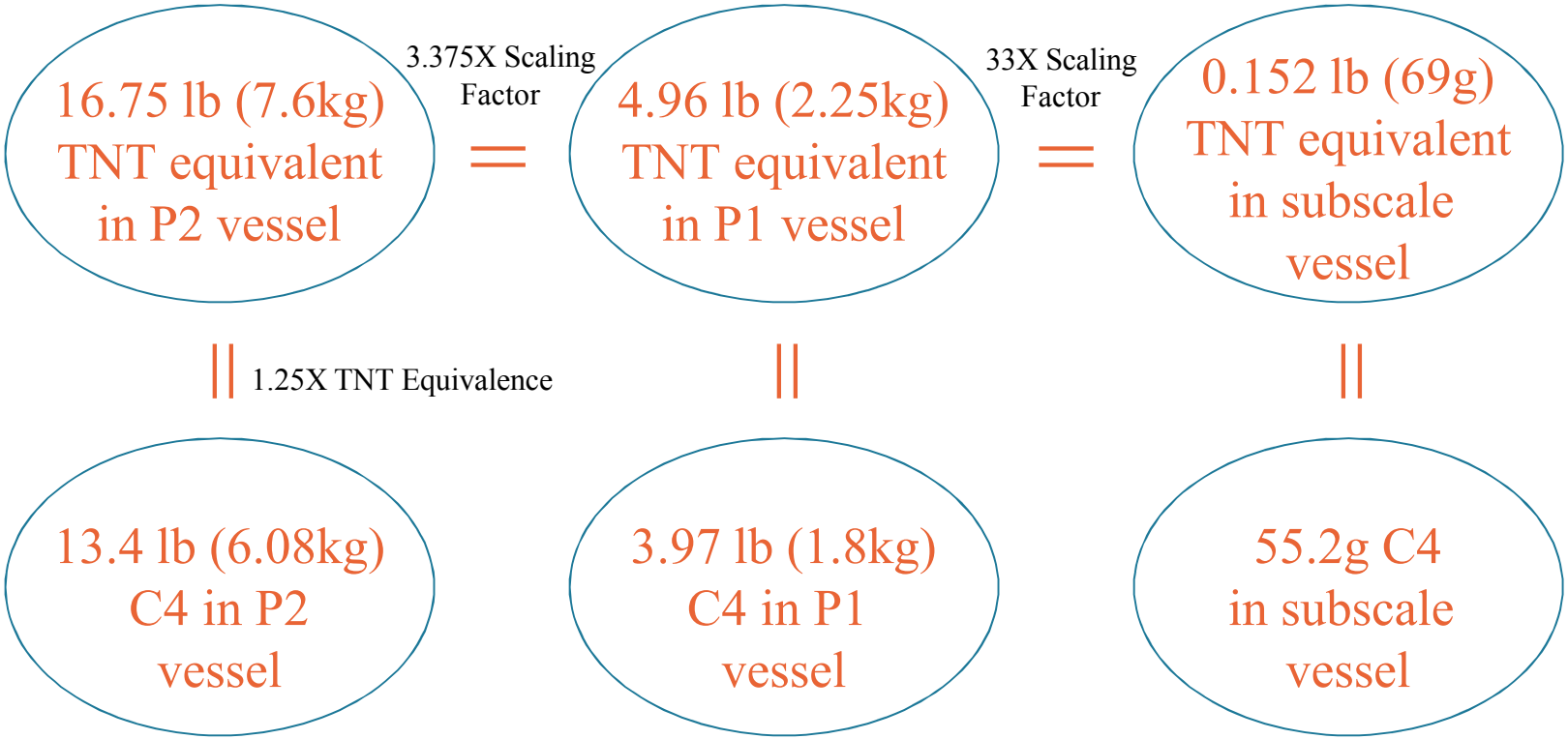
- P2U1 Vessel on trailer
  - Simulated GTR with AFSS – 16.75 lbs NEW
  - 16.75 pound bare charge – no FSS
  - 16.75 pound bare charge – no FSS
  - 16.75 pound bare charge – AFSS
  - 20.95 pound bare charge – no FSS
- P1U1 Vessel only
  - 4.85 pound bare charge – no FSS
  - Scaled GTR with AFSS – 5.12 lbs NEW
  - 14.5 pound bare charge – no FSS
  - 14.5 pound bare charge – no FSS
  - 14.5 pound bare charge – no FSS

  } = 50 lbs in P2
- Two subscale vessels
  - Repeated detonations to failure



Sandia National Laboratories

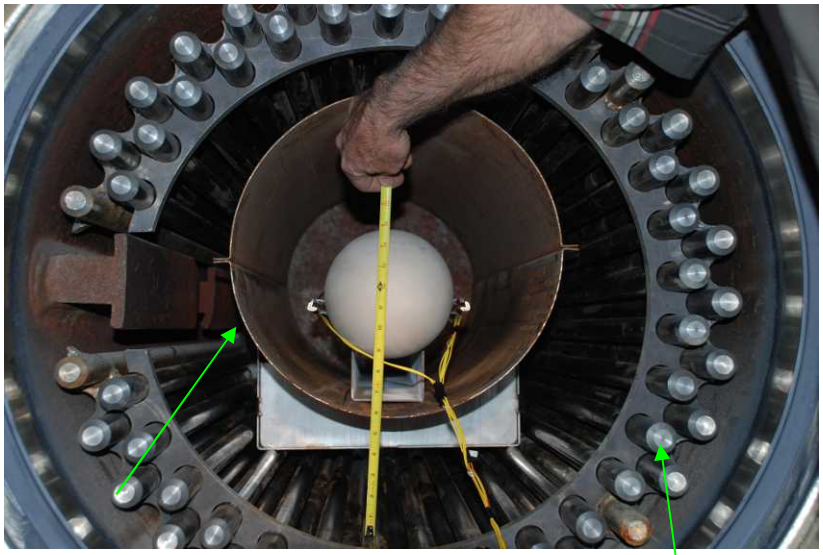
Explosive Quantities



Sandia National Laboratories

Advanced Fragment Suppression System (AFSS)

- Reusable
- Universal - Fits all munitions
- Less waste
- Handles larger events

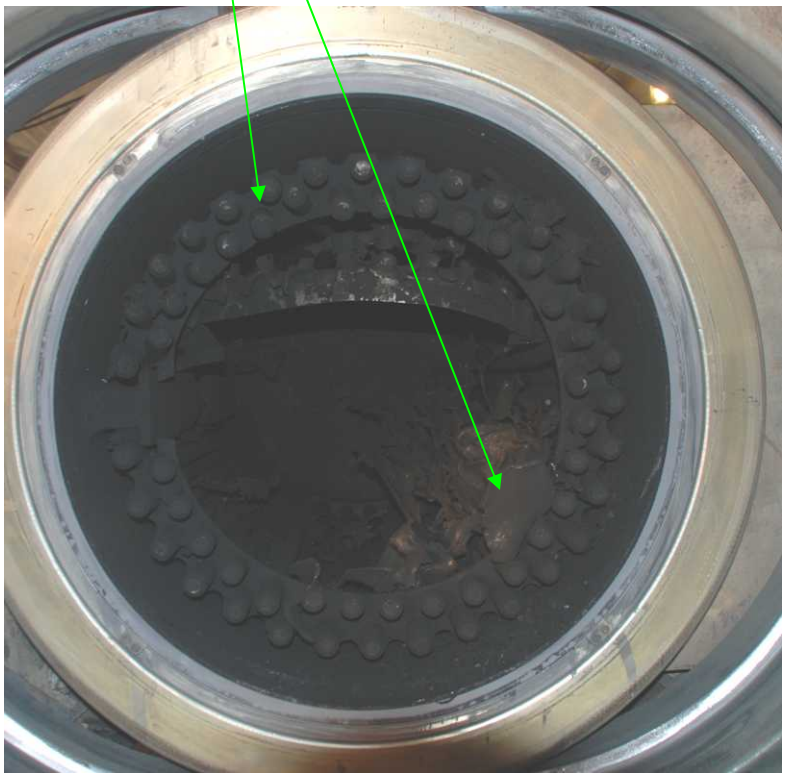


Thin sheet metal shell to mitigate LSC fragments

Series of steel bars held by flange at front and rear

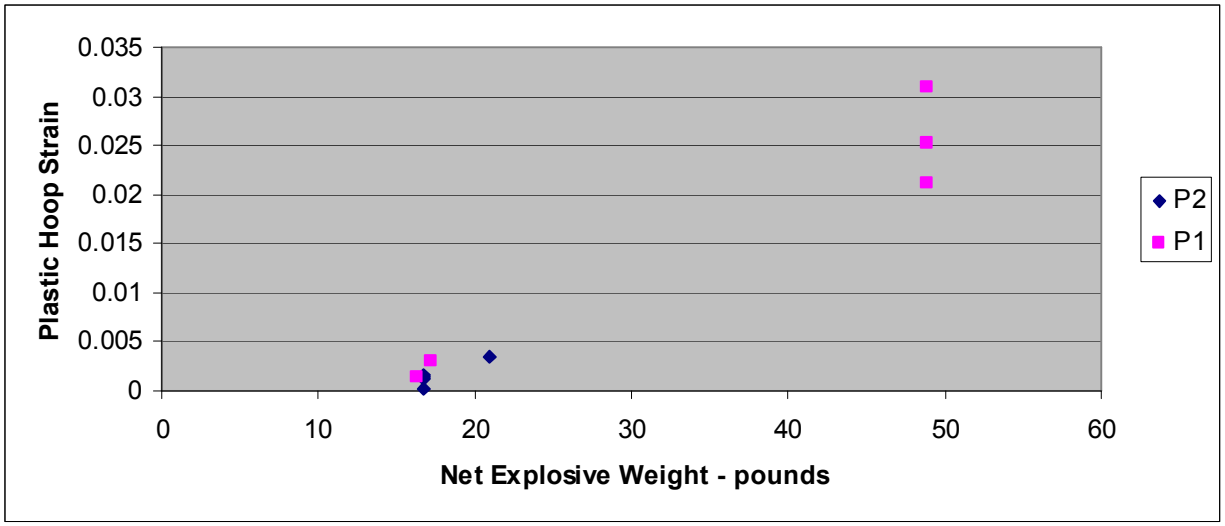
Many bars reuseable

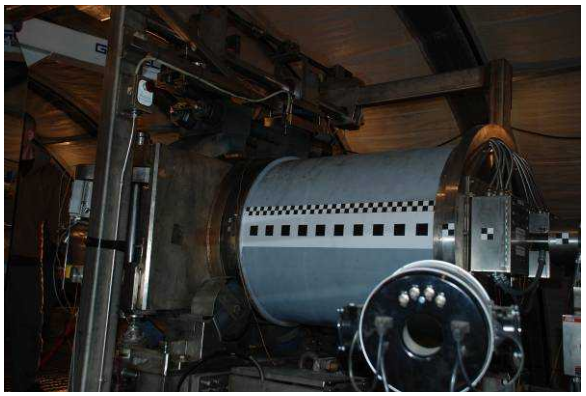
Fragments all contained in AFSS



Sandia National Laboratories

Structural Integrity of the Vessel





P2 after 21 lb test

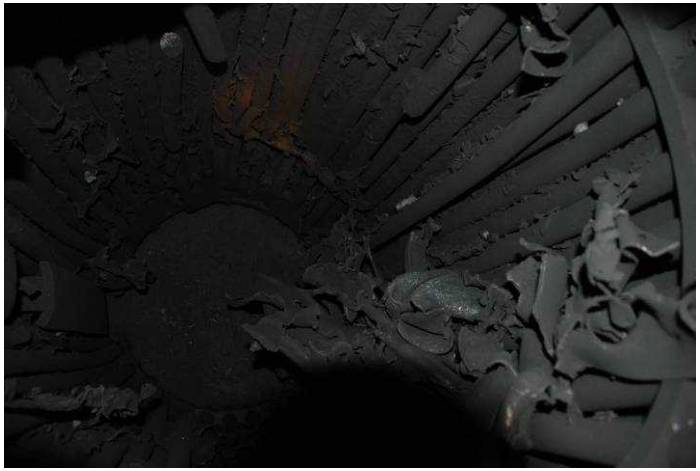
P1 after 14.5 lb tests

- 21 pound test produced 0.0033 strain
- 14.5 lb test in P1 produced .031 strain.
  - This is equivalent to 50 lbs in P2
- Subscale vessels failed at ~0.17 strain.
- The vessel structure could withstand more than 50 GTR detonations

Sandia National Laboratories

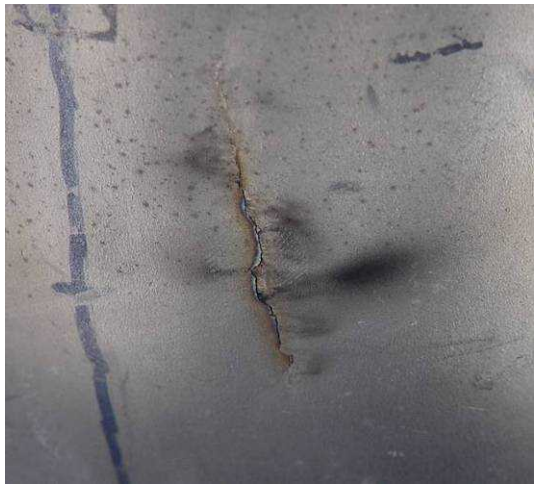
Integrity of Components

- AFSS adequately protected the vessel
  - Bars were not reusable
- Screws on door protector plates failed, but no permanent damage
- Clamps and fasteners were not damaged on any tests
- Grayloc gasket maintained seal on all P2 tests
  - Transient leak on first 3X test in P1
  - Enduring leak on subsequent 3X test
  - Leak rate typically less after detonation
- Valves and fittings survived all P2 tests
  - Fittings leaked on 3X test in P1
- No damage to other EDS hardware on trailer
  - Vessel rotated freely after the tests
  - Heaters were not tested

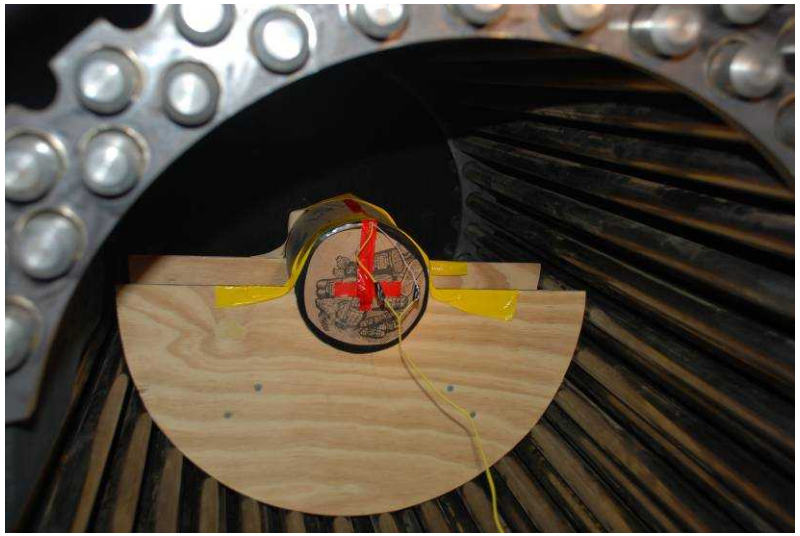


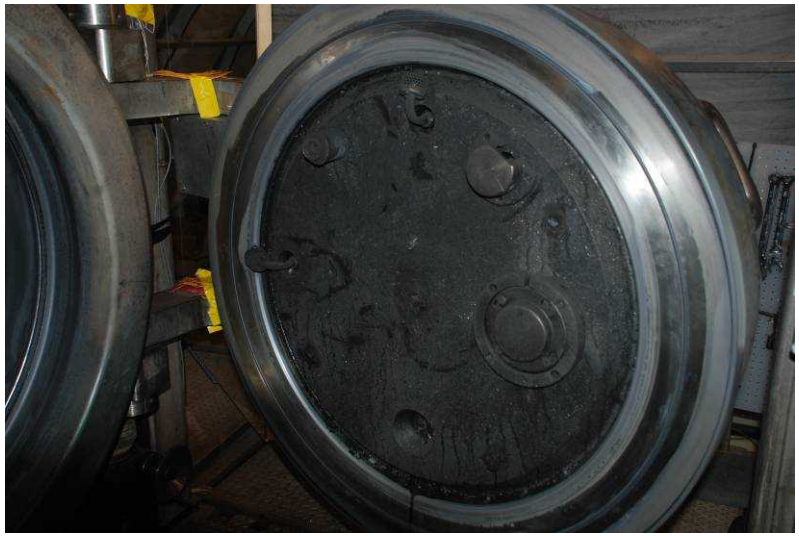
Vessel Will Leak Before Burst

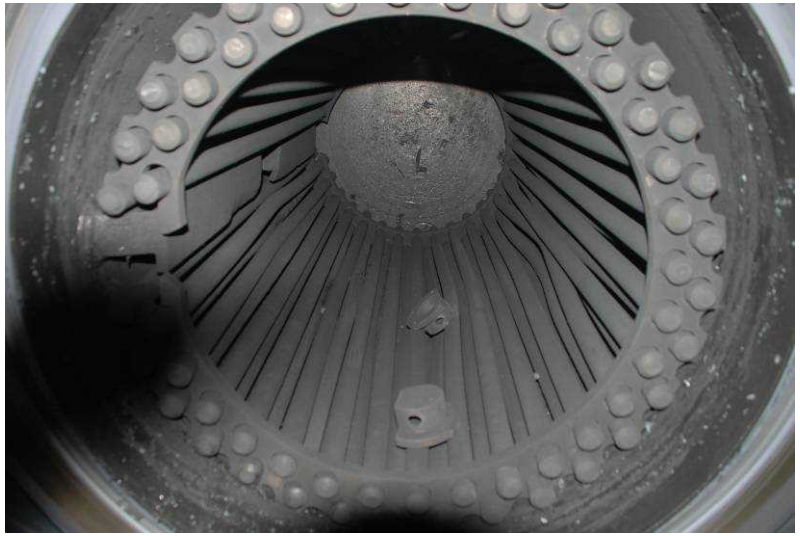
- Initial failures occurred in valves and fittings
  - Not catastrophic
  - Agent still contained in EE
  - Able to reseal
- Transient failure of Grayloc seal occurred next
  - Associated with large deformation of the seal surface
- Ultimate vessel failure results from accumulated strain
  - Subscale vessels demonstrate leak before burst



17lb Bare Charge with AFSS

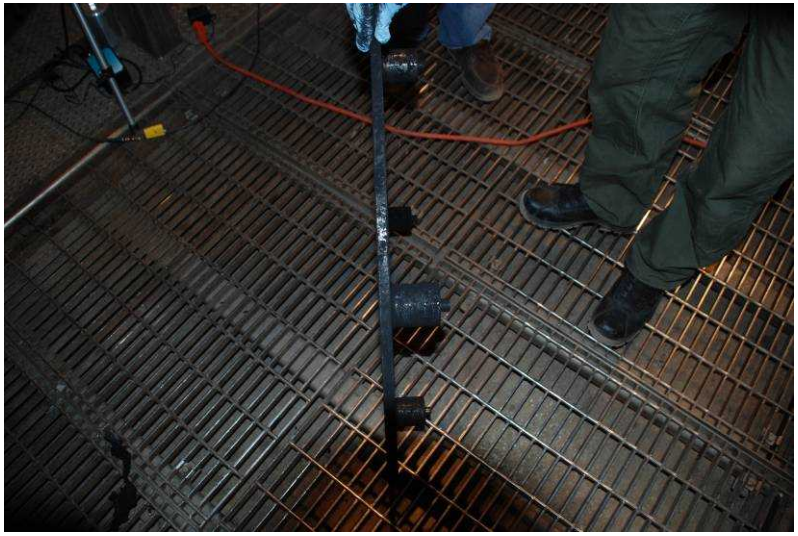






Sandia National Laboratories

AFSS After Mock GTR



P2 Vessel After Test Series

Conclusion

- Probability of GTR propellant detonating is small
- ASME code case supports use of EDS at larger levels
- EDS can contain the worst case detonation of a GTR
  - Minimal damage to vessel
  - Able to complete the operation
- AFSS offers several advantages and can protect the vessel in a large event such as a GTR detonation
- EDS can safely process German Traktor Rockets with propellant