

SPE-180311-MS

Finite Element Modeling to Determine Perforating Gun Collapse Failure Modes and an Engineered Solution

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Agenda/Introduction

- Introduction
- Collapsed Gun Event Analysis
- Collapsed Gun: Event Mitigation
- Discussion

Perforation Gun System Events

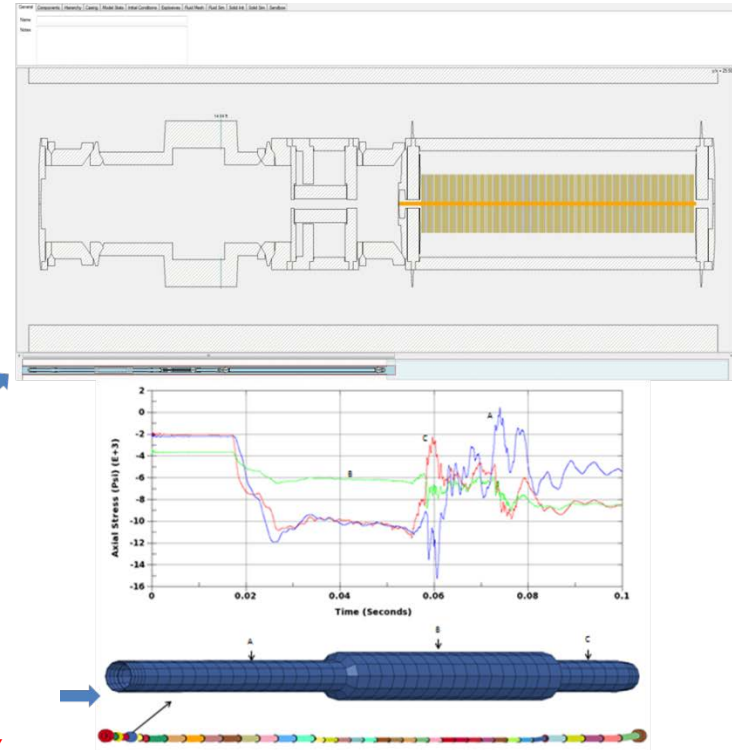


Perforation Gun System Events

- Anomalous events during a perforation:
 - \$\$\$
 - Delay
 - Damage of image

- Suggests that software that simulates an event can:
 - Understand how the event occurred
 - Prevent events before they occur
 - Look at stress on toolstring parts
 - Design tools

Our shock simulation is a 3-D FEA-based tool with a GUI front end specifically for generating tool strings

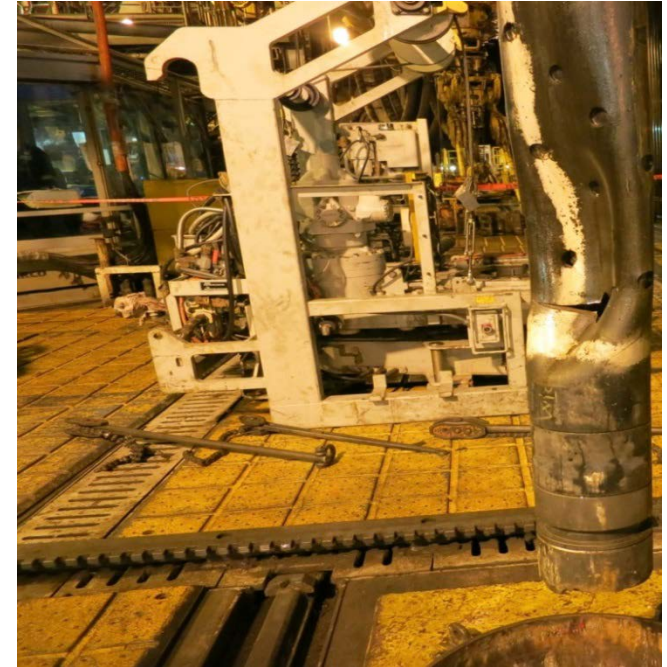
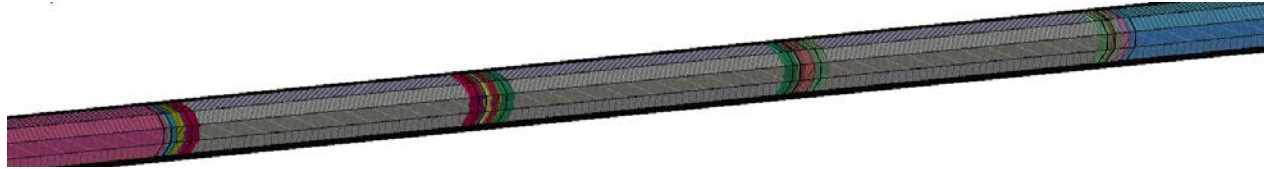


3-D FEA-based Shock Simulation Tool

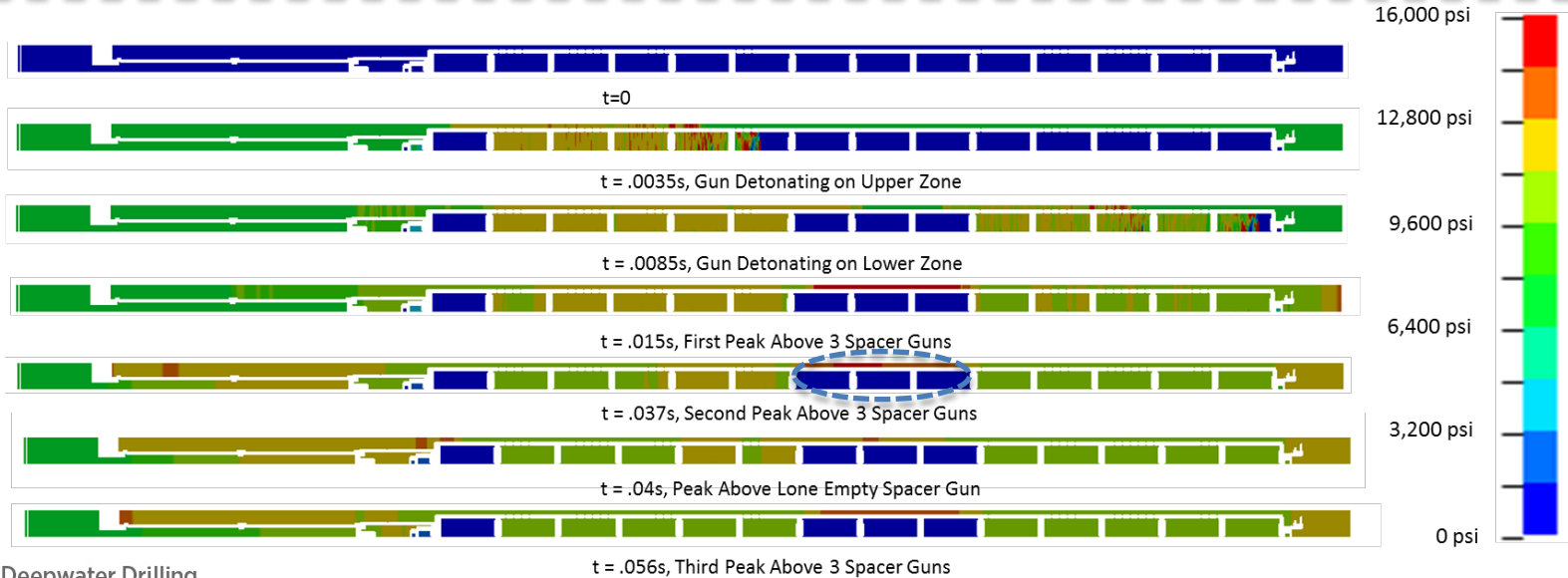
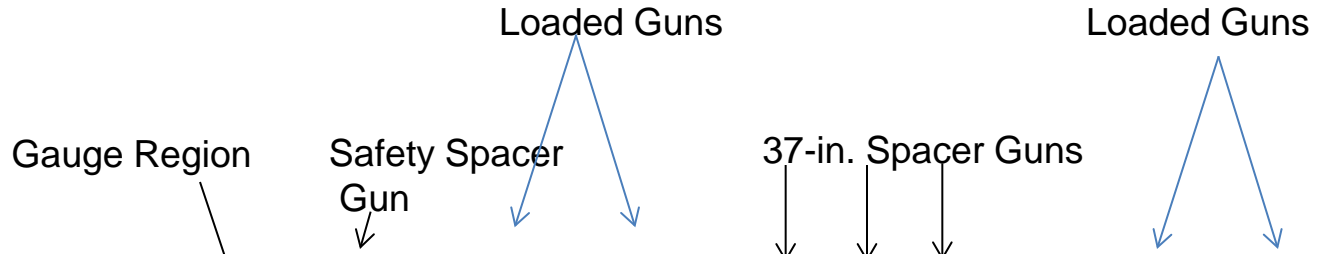
- Proprietary tool database and model generator enable the following:
 - Definition of bottomhole-assembly (BHA) geometry and wellbore fluids
 - End users without prior FEA analysis experience can set up complex models quickly and reliably
- Commercial solver used to run the dynamic analysis
- Results include:
 - Dynamic pressure and loads during the perforating event
 - Interaction of pressure and structural waves within the BHA and wellbore
 - Three-dimensional (3-D) visualization of loads and pressures

Collapsed-Spacer Event Example

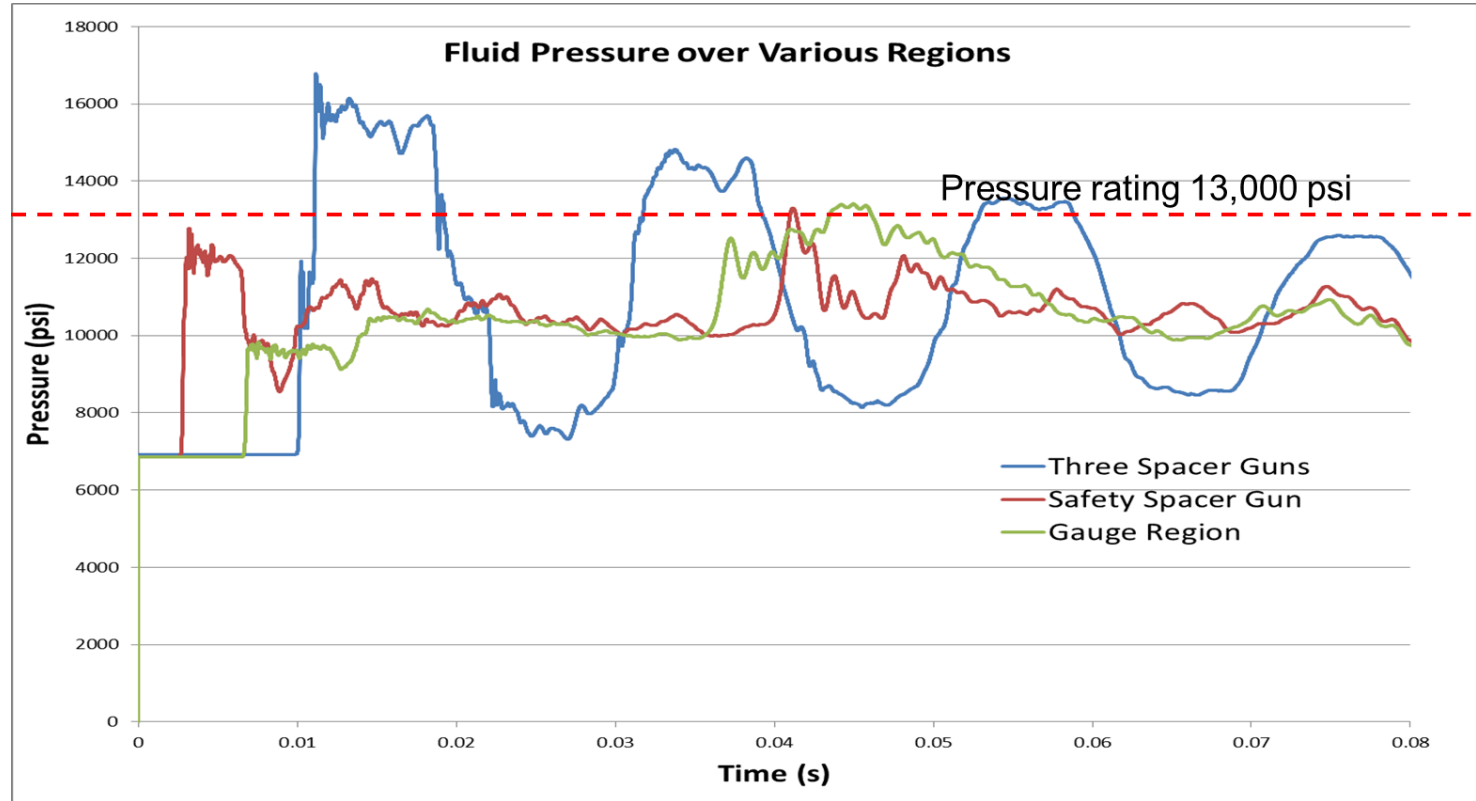
Illustrative
Movie



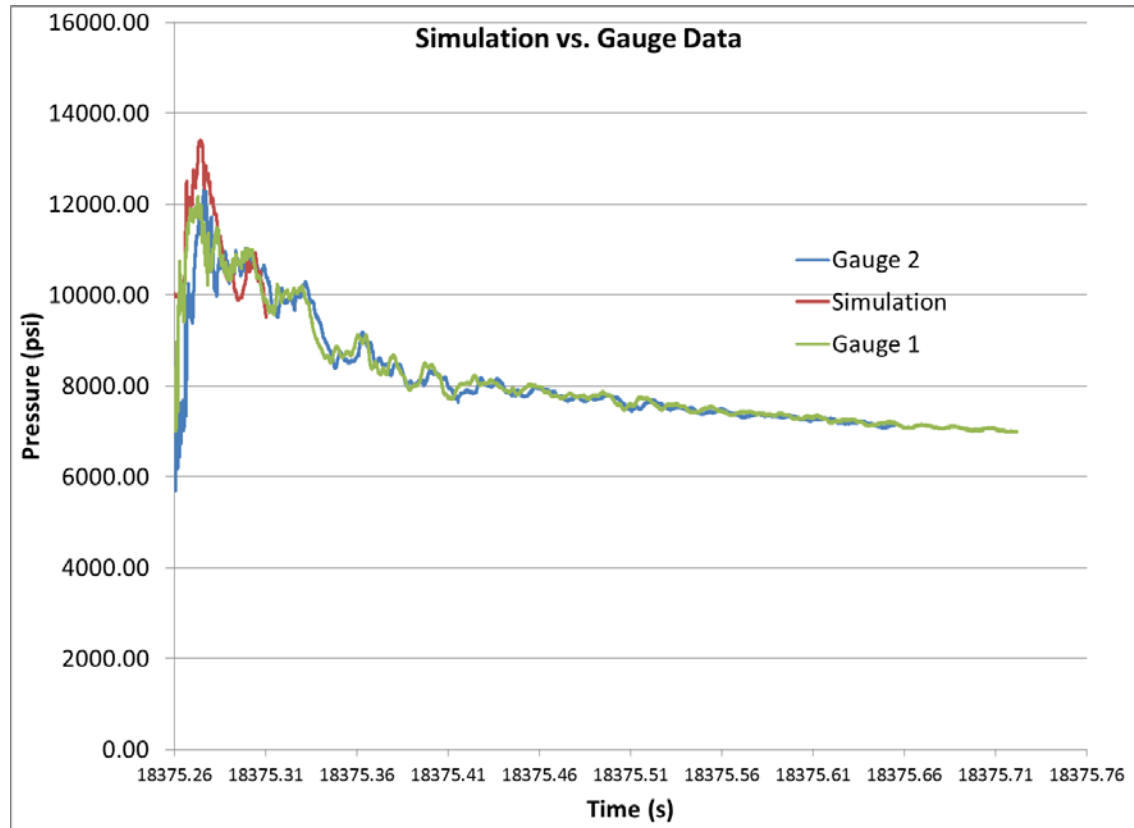
Setup and Stills



Pressure Over Three Center Spacers Exceeds Rating



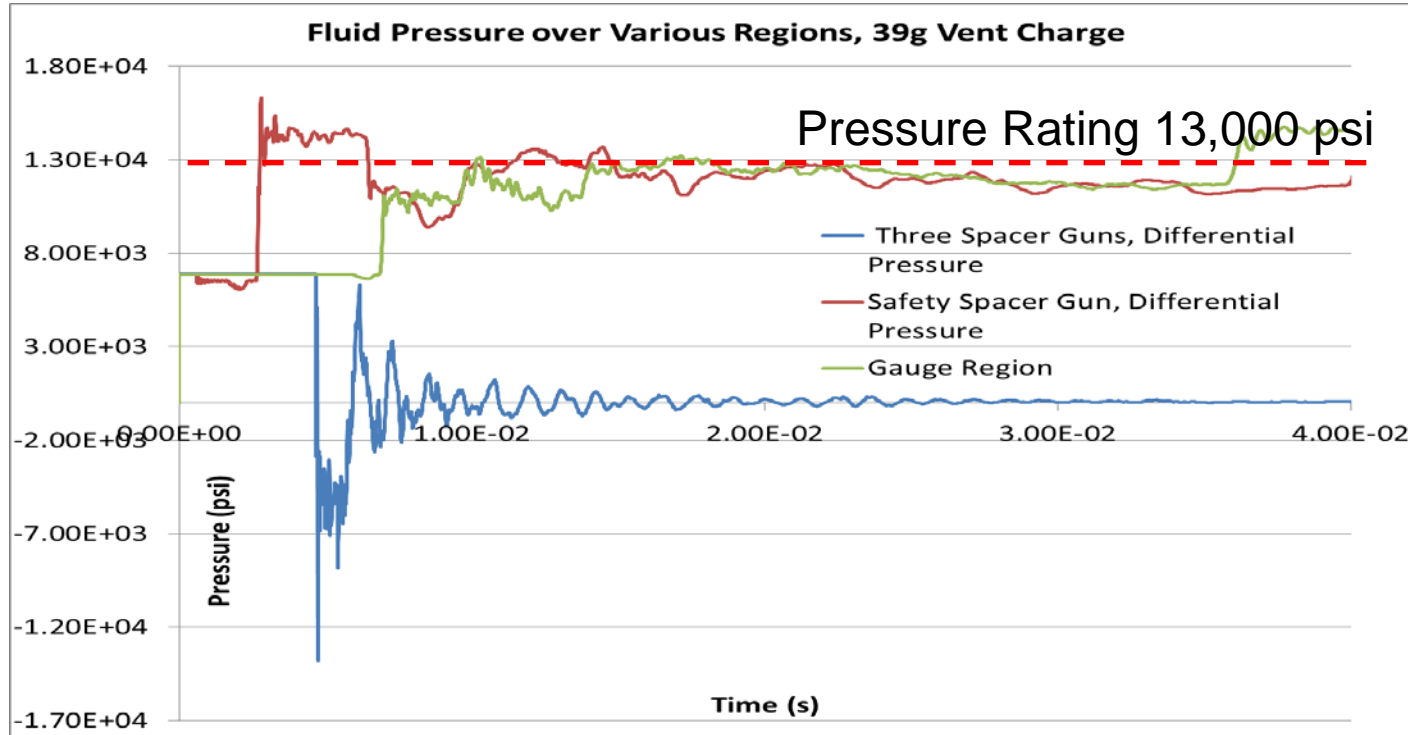
Gauge Data and Simulation: Time-Shifted Comparisons Reasonable



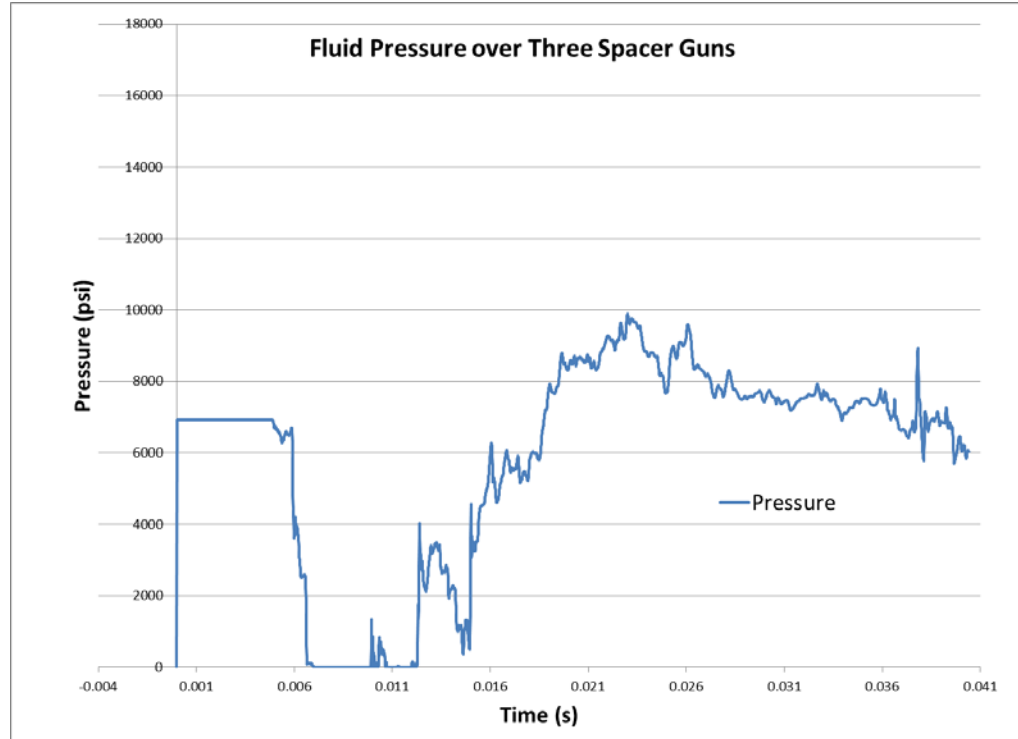
Use 3-D FEA-based Shock Simulations Tool to Explore Possible Event Mitigation

- 39-g vent charge
- 6-g vent charge
- 4-5/8-in. spacers
- 7-in. heavy-wall spacers

Event Mitigation: 39-g Vent Charge Stresses Safety Spacer

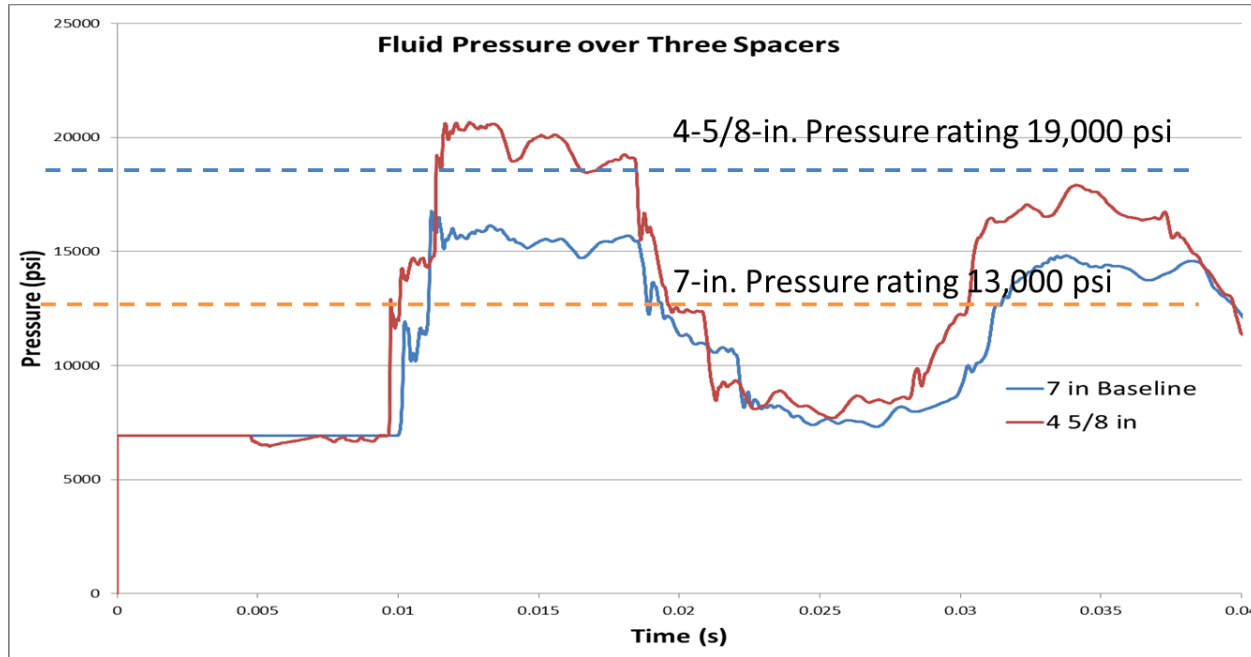


Event Mitigation: 6-g Vent Charge Draws Fluids and Materials into Gun



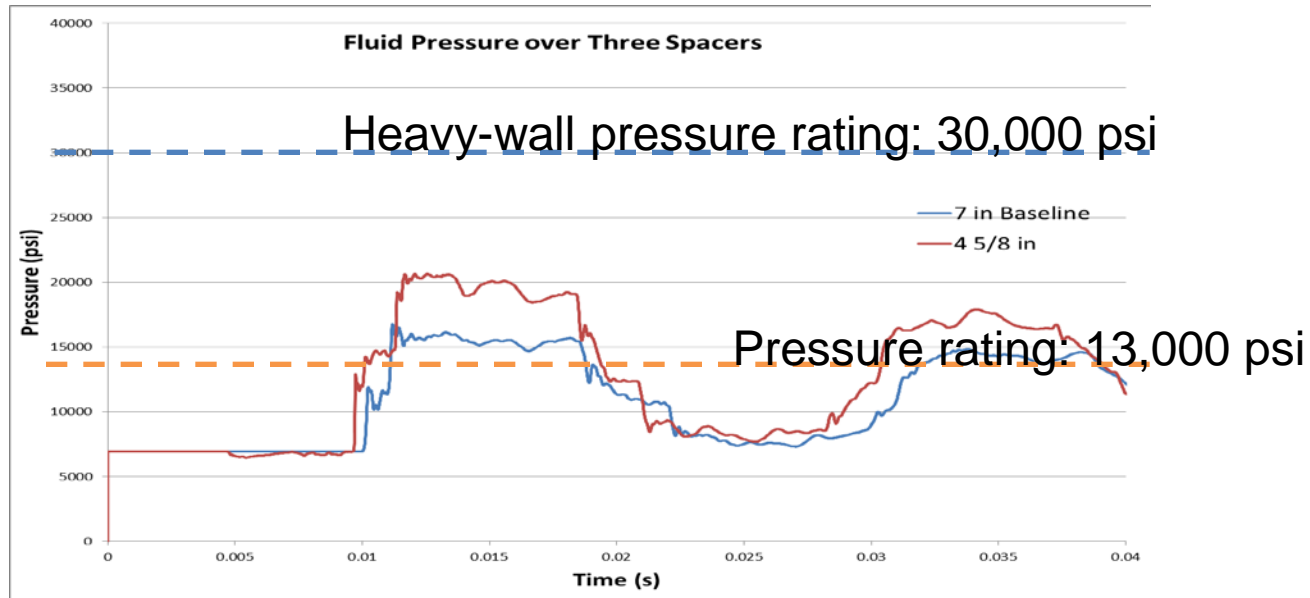
Event Mitigation: 4-5/8-in. Spacers Solution is Marginal

4-5/8-in. guns



Event Mitigation: 7-in. Heavy-Wall Spacers Solution is Realizable

7-in. guns with thick walls



Discussion

- Collapse event simulated by 3-D FEA-based shock-simulation tool
- By understanding these events, possible solutions can be explored:
 - 39-g vent charge stresses safety spacer
 - 6-g vent charge draws into gun
 - 4-5/8-in. gun (19,000-psi pressure rating) is marginal
 - 7-in. heavy-wall gun (30,000-psi pressure rating) has significant higher safety margin

Acknowledgements / Thank You / Questions

Acknowledge Federico Rios for helpful discussions

