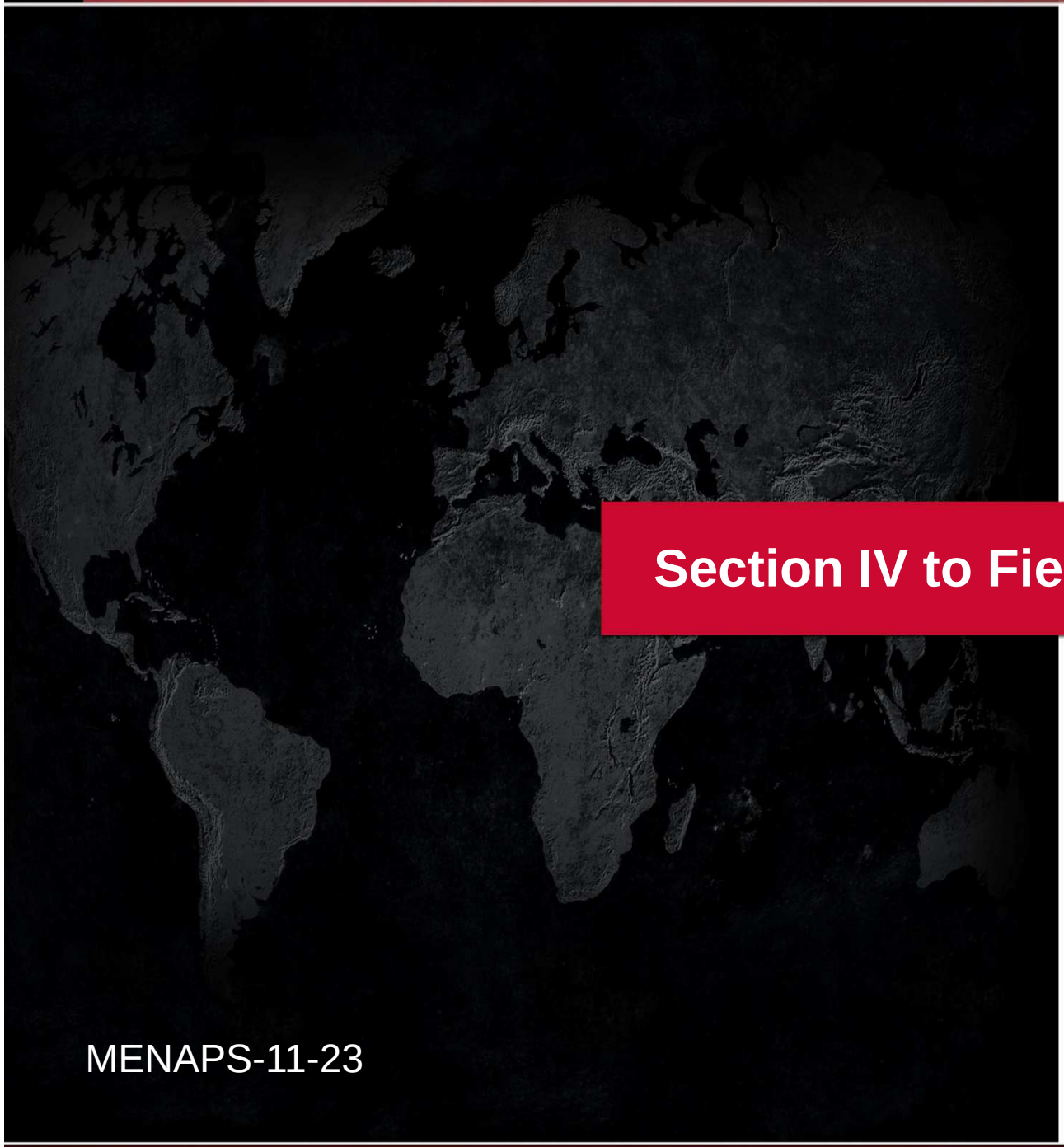

Section IV to Field (DUB)

Dennis J. Haggerty, JRC-Halliburton
Cam Le, Halliburton

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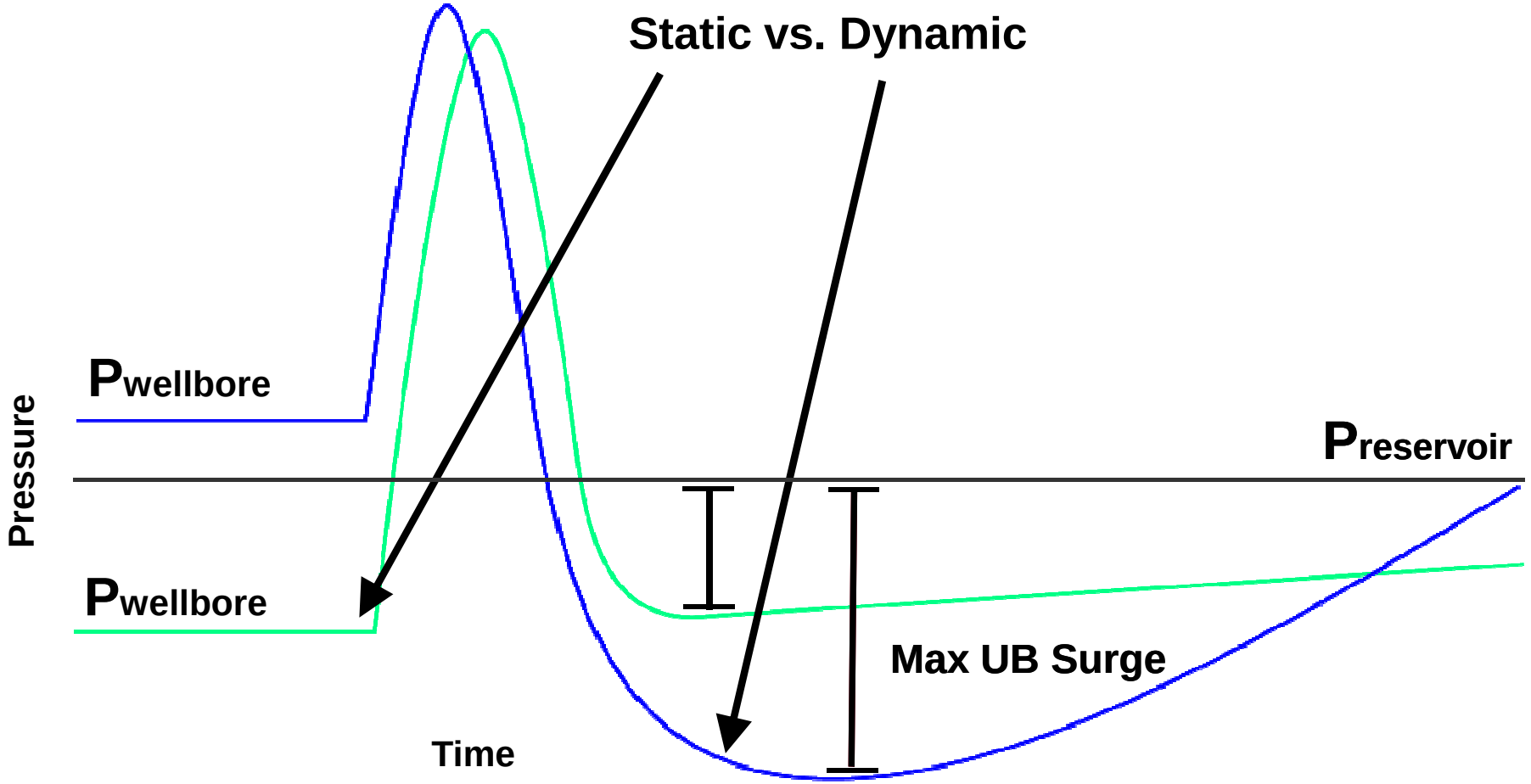
HALLIBURTON

Defining Dynamic Underbalance (DUB)



Customer Challenge

- Injector well
- Initial Well Parameters
  - ~ 6000 psi BHP
  - ~ 190 F BHT
  - ~ 450 md
  - ~ 25% Φ
  - ~ 20,900 ft MD TVD
  - ~ 3,850 ft Water Depth
  - ~ 3500 psi Overbalanced by Seawater

Customer Challenge

- Zinc or Steel
  - Which would increase injectivity when shot in an **severely overbalance** condition? **3,500 psi**

- How much Dynamic Underbalance (DUB) is needed to improve injectivity?

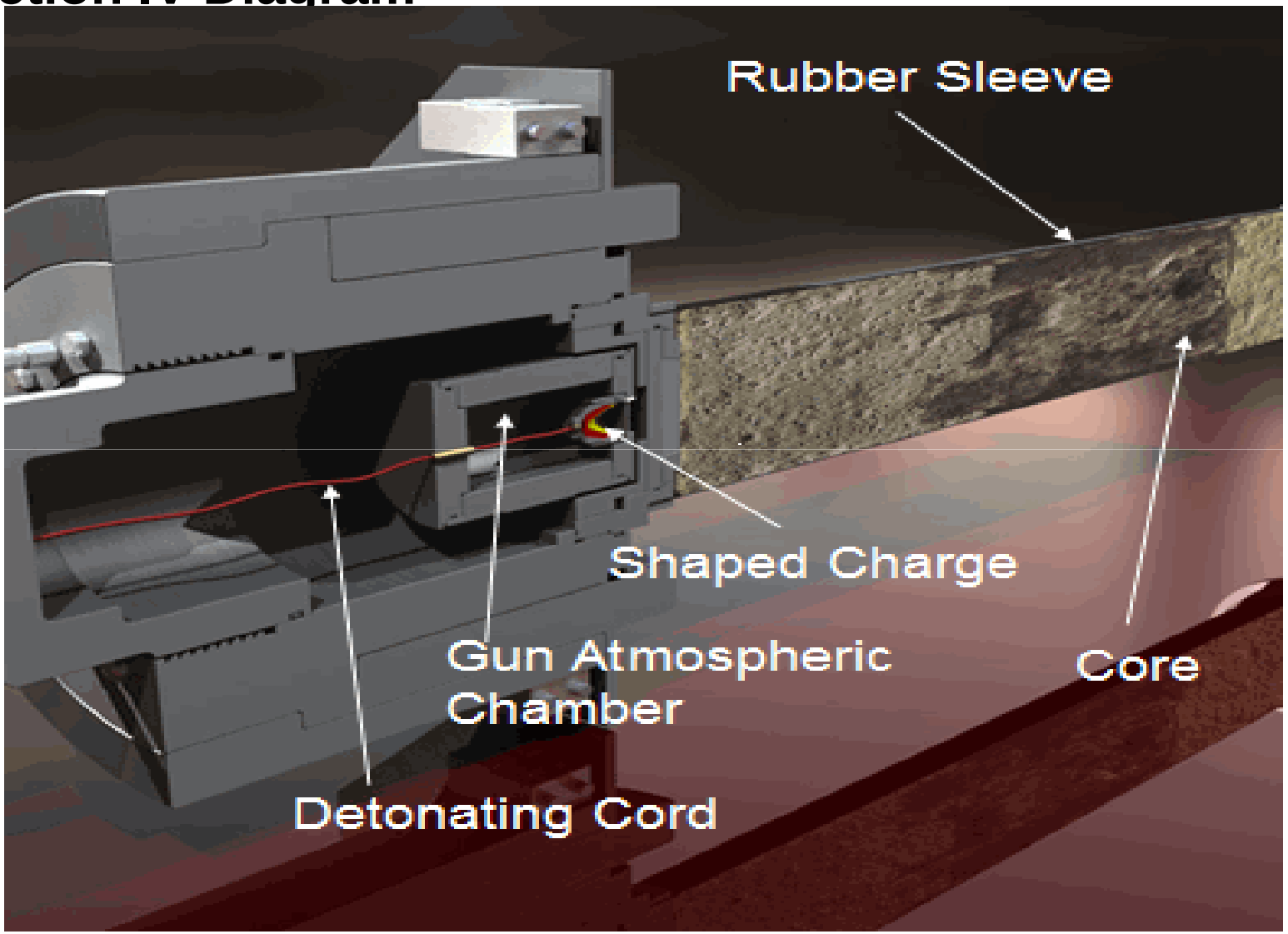
- Estimate the injection rate

Section IV Approach

- Lab Set Up
  - Section IV Diagram
  - Gun Setup – FGV (free gun volume)
  - Parameters

- Lab Results
  - Pressure Response
  - Injectivity

Section IV Diagram



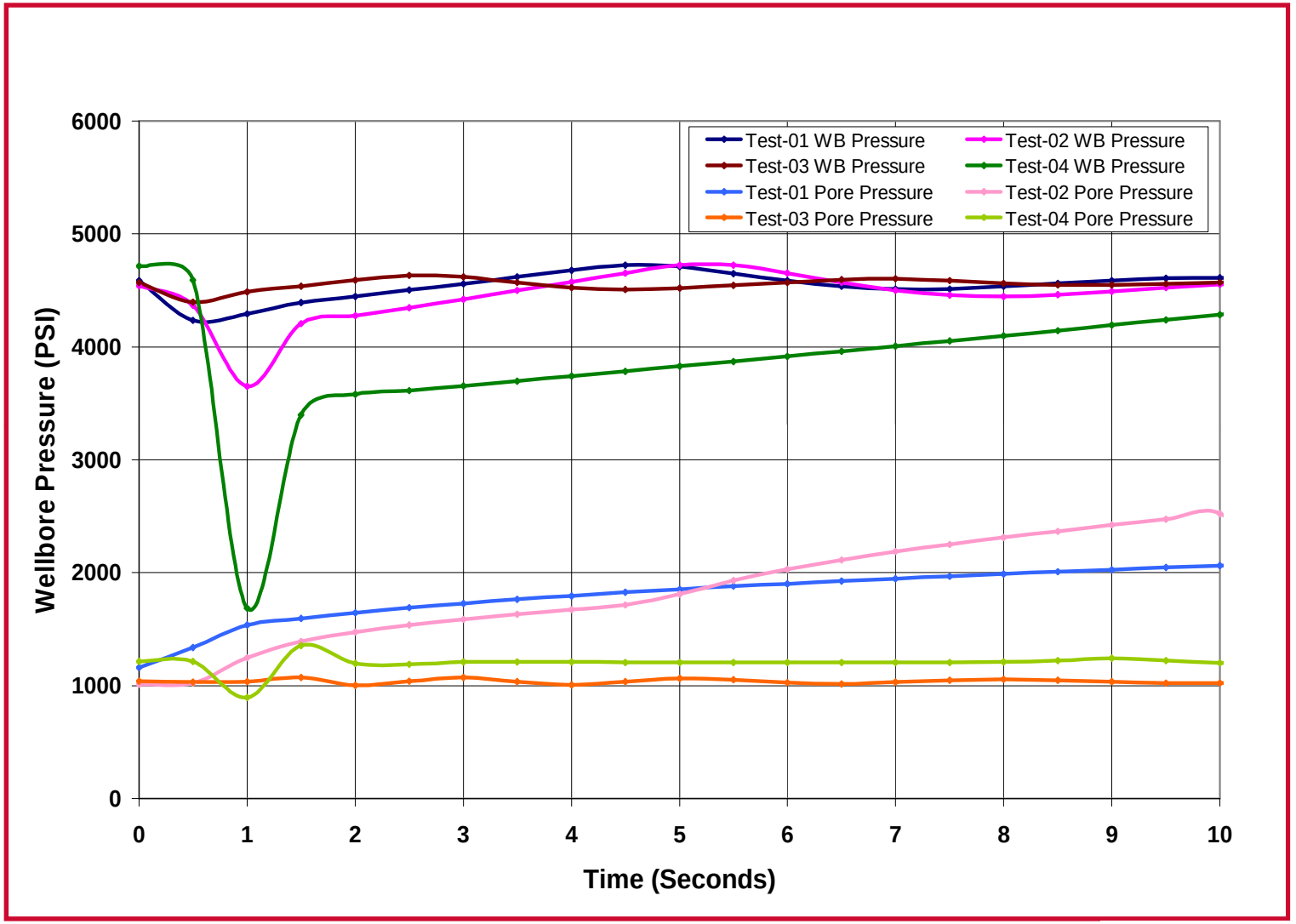
Section IV Parameters

Test Number	SPF	Free Gun Volume, cc	Overburden Pressure, psi	Pore Pressure, psi		Wellbore Pressure, psi	Overbalance Pressure, psi
1 – Zinc	12	515	5,000	*Net Effective Stress psi*	**1,000**	**4,500**	**3,500**
2 – Steel	12	515					
3 – Steel	21	83					
4 – Steel	2	1100		*4,000*			

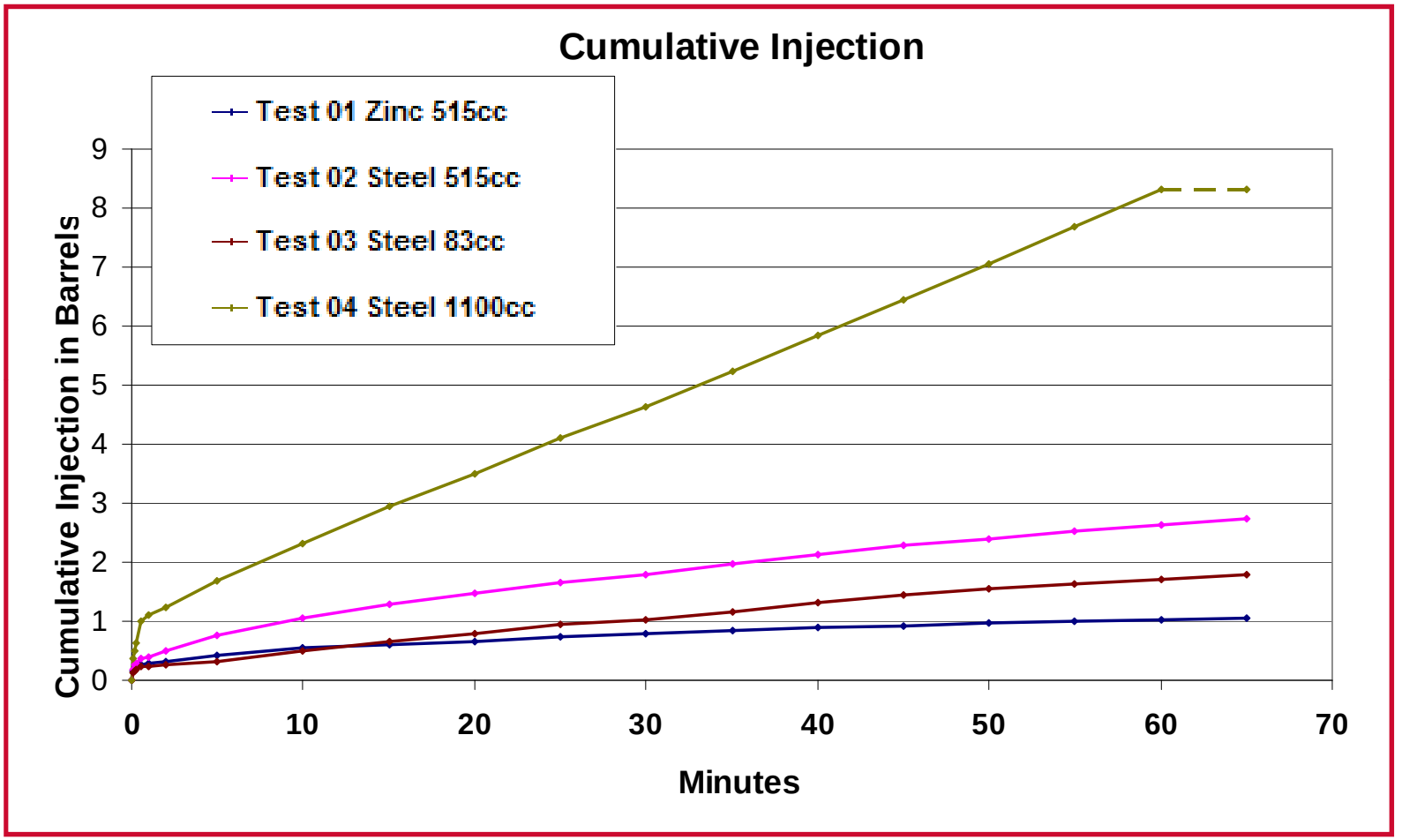
- Test 1 – Fully loaded Zinc Gun
- Test 2 – Steel with same FGV for and apples to apples comparison
- Test 3 – Fully loaded Steel Gun
- Test 4 – Extreme case to increase FGV to induce a DUB response

- Charges:
  - 5 in. 12 SPF RDX SH Mirage
  - 5 in. 21 SPF RDX BH Cluster
- Fluid Gap: 0.80 in.
- Casing: 0.50 in. 4140 steel
- Cement: 1.55 in. Class A Neat
- Wellbore Fluid: 3.5% NaCl

2Hz Pressure Traces after Perforation



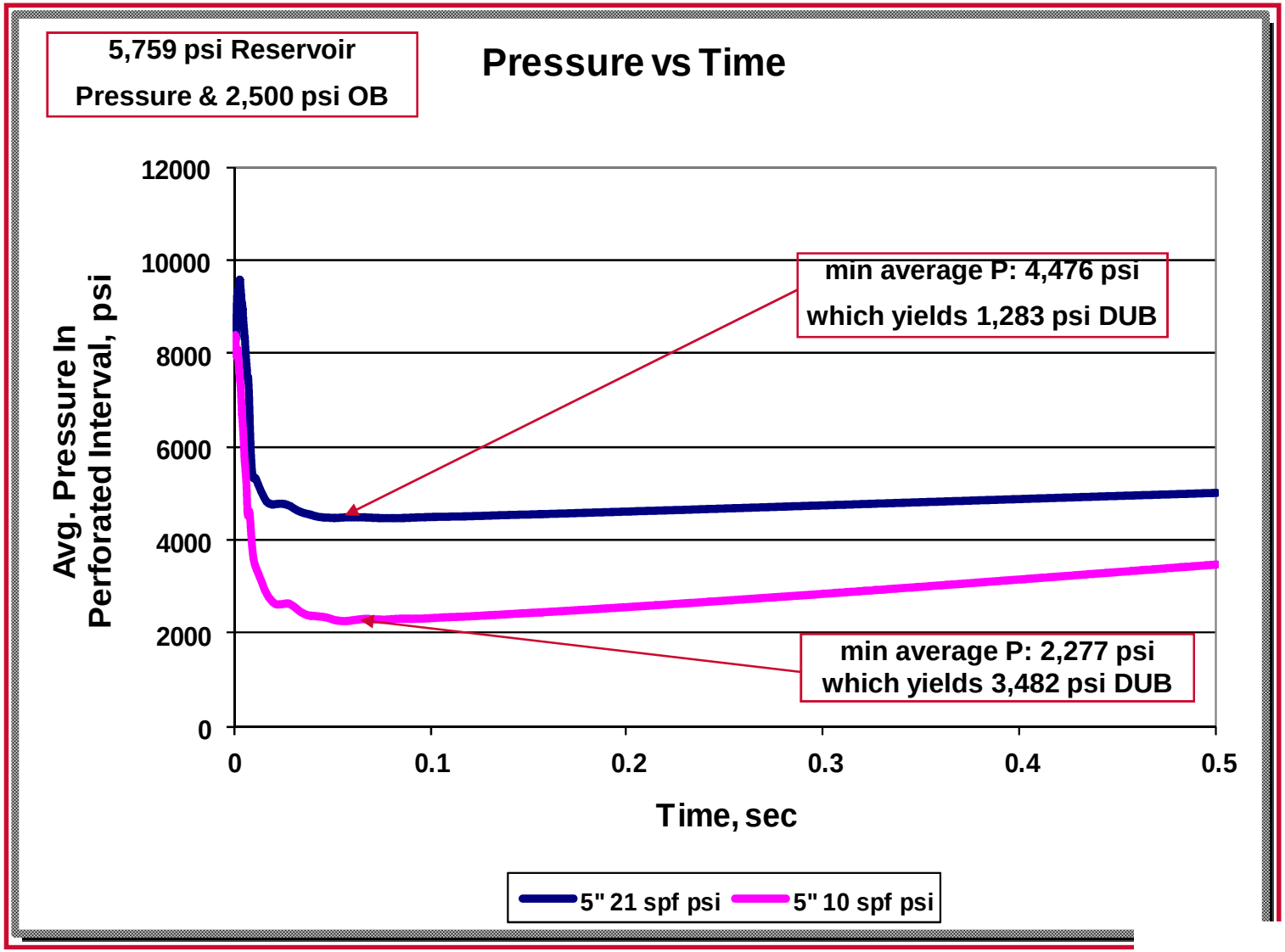
Injectivity



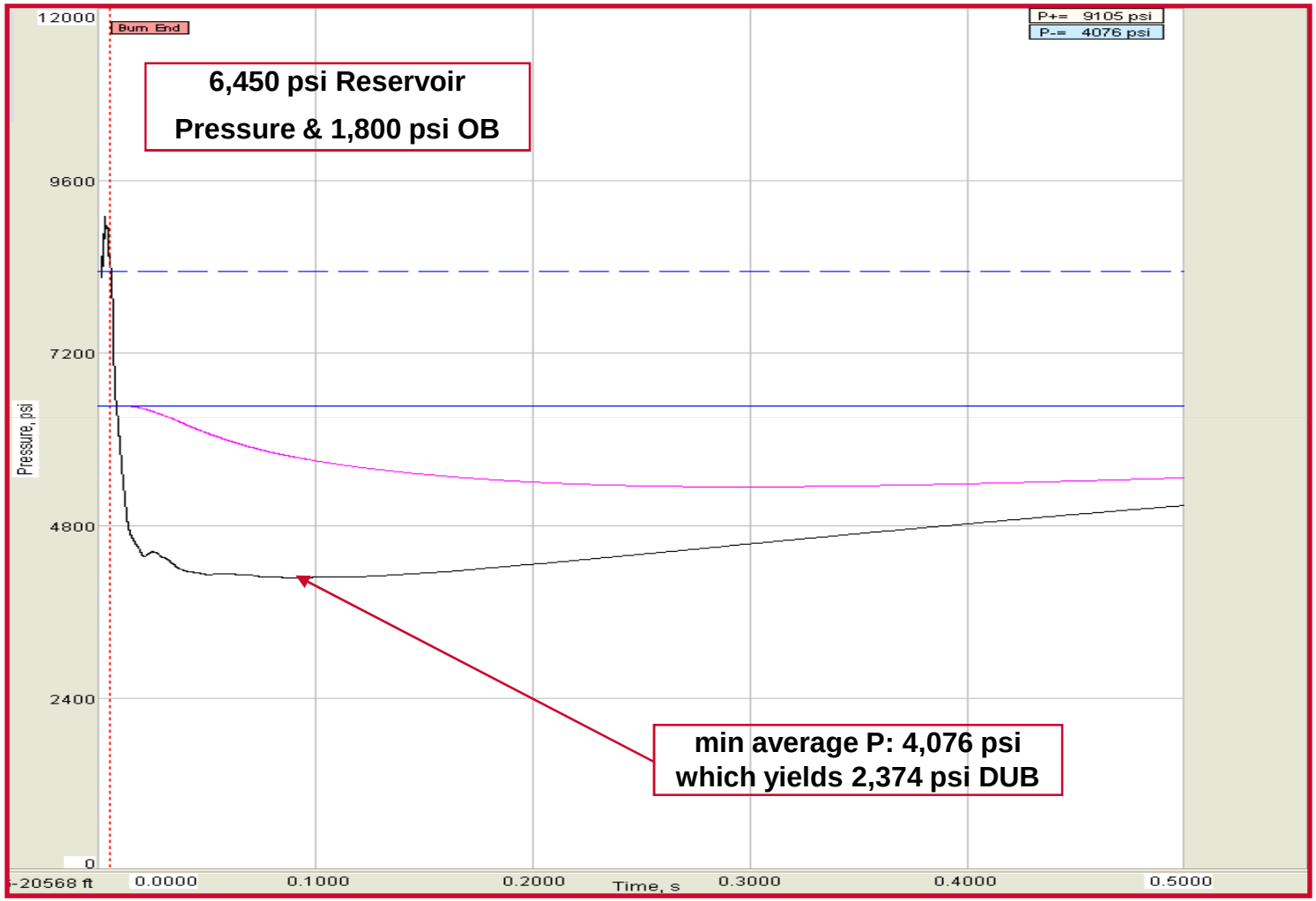
Dynamic Surge Modeling

- ?’s that needs Answers
  - How does a full system at actual down hole condition and geometry perform?
  - Do we need the additional Free Gun Volume (FGV)?

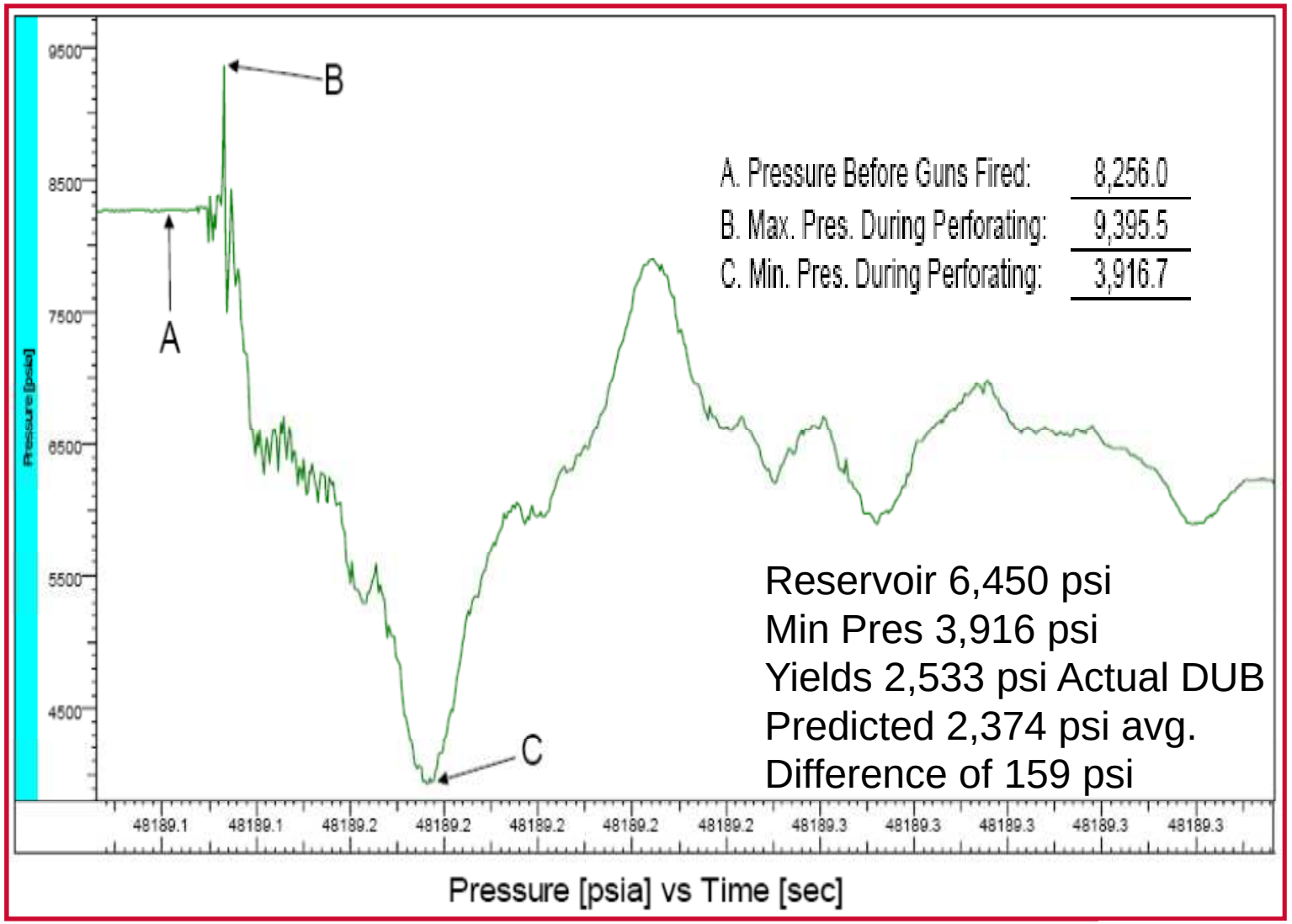
Gun Selection Based on Predicted DUB



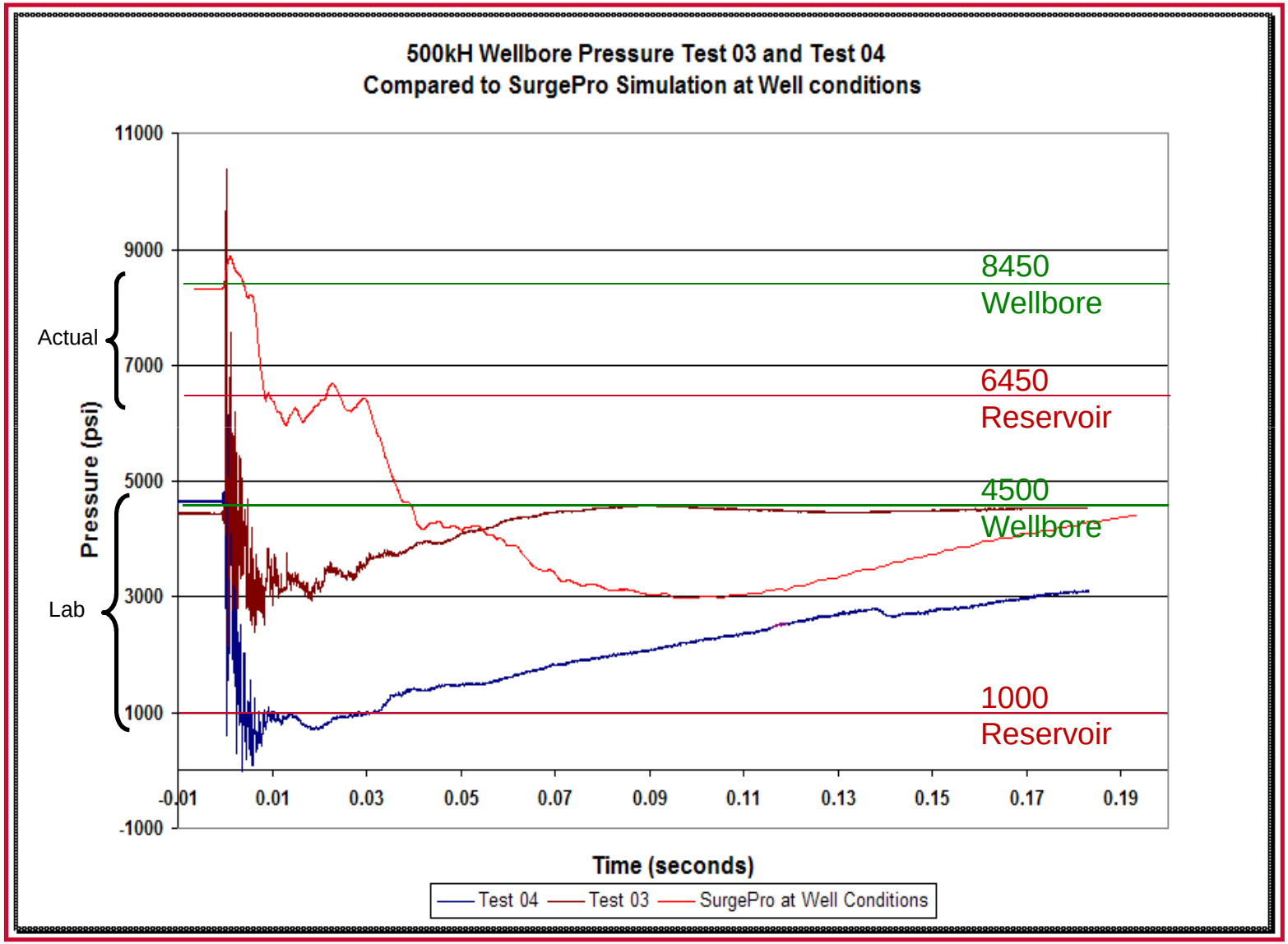
Updated Model to New Parameters



High Speed Data Validating Model



Comparing Lab Results to Model



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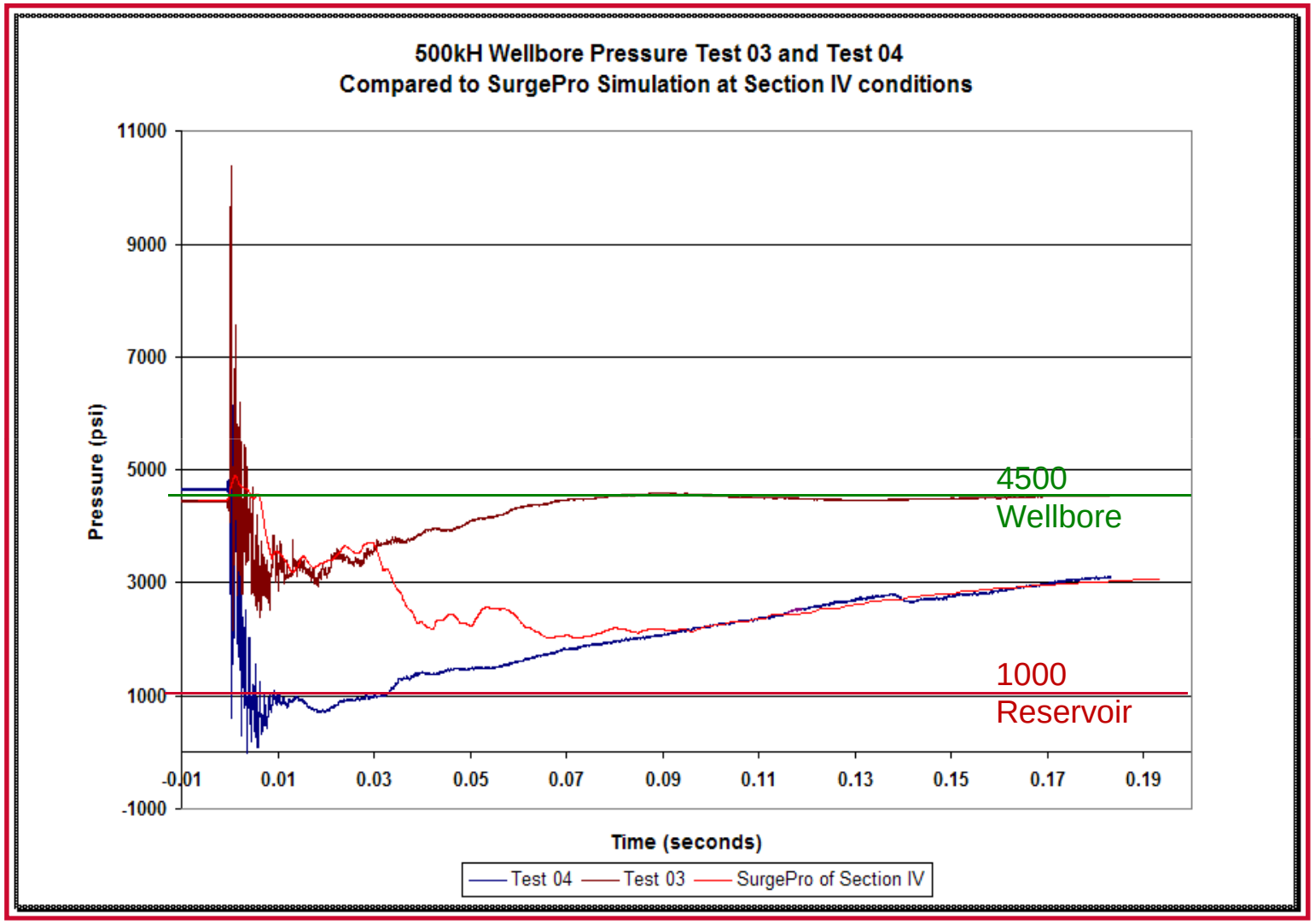
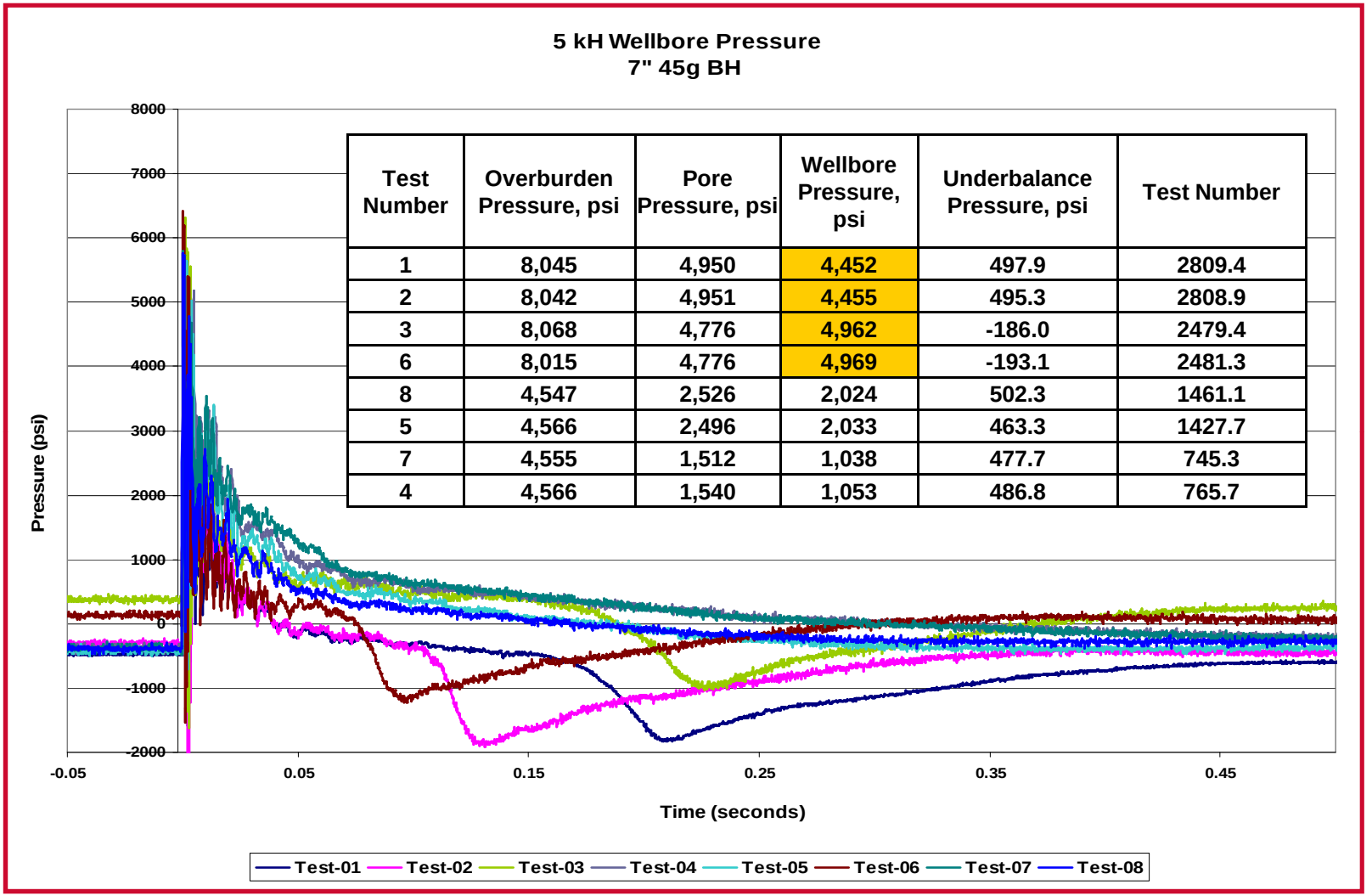
Rerun Model at Section IV conditions



Supporting Data



Test Number	Overburden Pressure, psi	Pore Pressure, psi	Wellbore Pressure, psi	Underbalance Pressure, psi	Test Number
1	8,045	4,950	4,452	497.9	2809.4
2	8,042	4,951	4,455	495.3	2808.9
3	8,068	4,776	4,962	-186.0	2479.4
6	8,015	4,776	4,969	-193.1	2481.3
8	4,547	2,526	2,024	502.3	1461.1
5	4,566	2,496	2,033	463.3	1427.7
7	4,555	1,512	1,038	477.7	745.3
4	4,566	1,540	1,053	486.8	765.7

Lessons Learned

- When parameters are the same; Section IV and Model DUB results are similar
- API Section IV Labs were build on the principle of net effective stress therefore Dynamic Surge Model needs to be run to account for the absolute differential between wellbore and gun
- Model has been validated by field data
- Model can be use to customize the gun system and tool string to optimize the DUB