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Wellbore Implosion: Case Study of Perforation Enhancement

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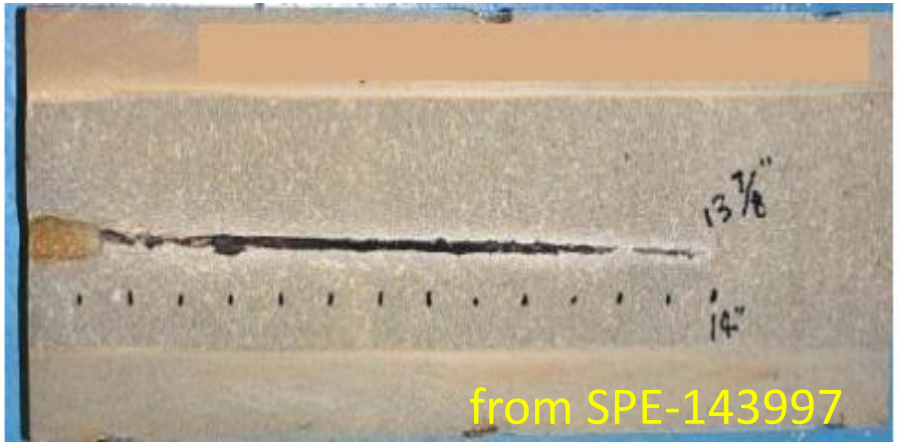
AGENDA

- Field Background
- Perforation Damage
- Dynamic underbalance technique
- Wells candidates
- Pre-job simulation
- Operation
- Wells performance

INTRODUCTION

- Field on land in Oman with more than 250 producers and injectors
- Sandstone 1500m deep at 50mD and 20% porosity.
- 4.5” or 7” cemented casing.
- Water injection started in January-2013 but some wells with low injectivity.
- Perforating system including reactive liner charges and propellant tried but result was not satisfactory.
- This case study is about dynamic underbalance post perforating (DUB-PP)

Perforation Damage



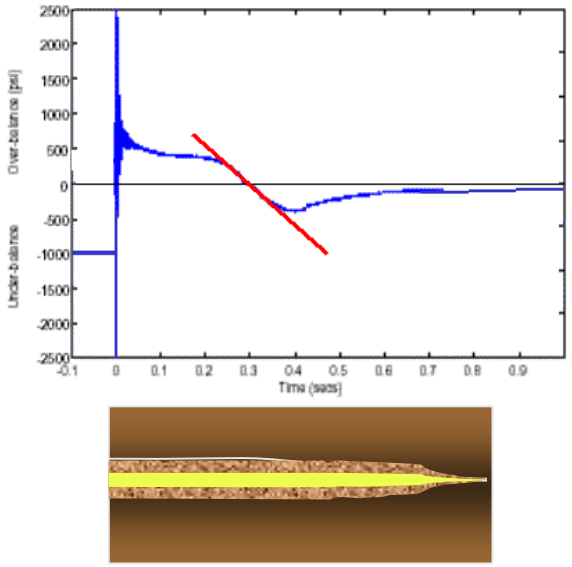
Conventional Perforating

Dynamic Underbalance Perforating

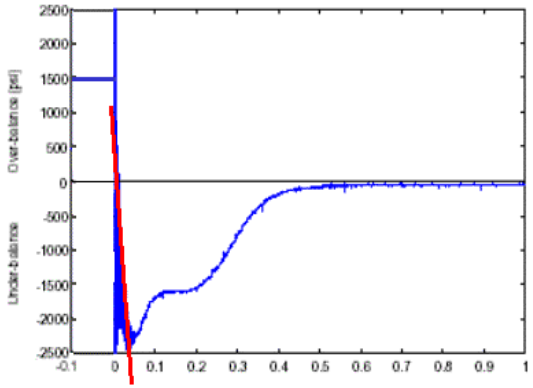
- Perforation damage:
  - Plugged tunnels
  - Low permeability crushed zone around the tunnel

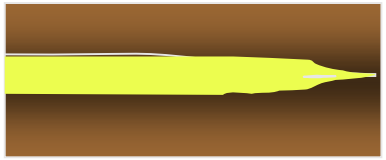
Why Dynamic Underbalance ?

- Dynamic underbalance aka Wellbore Implosion
- Magnitude and sharp pressure drop is key to break (fail) the crushed zone, leading to cleaner perforations.
- Design guns to achieve dynamic wellbore implosion pressure event.



Conventional Underbalance

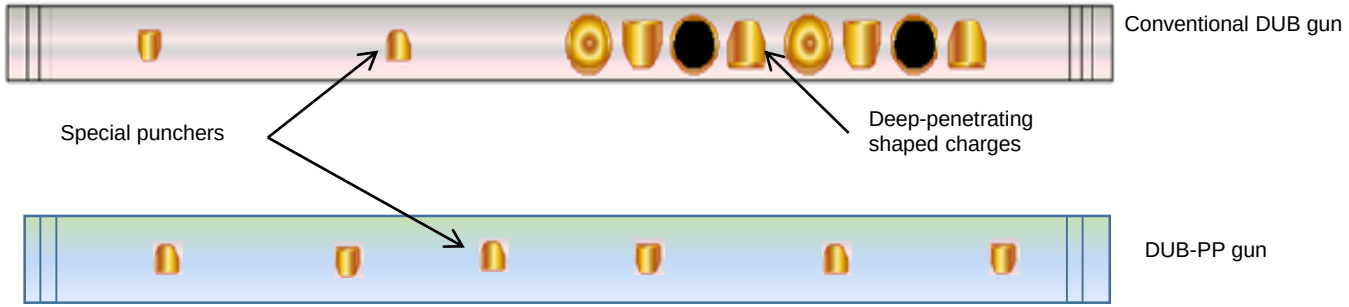




Dynamic Underbalance

Dynamic Underbalance (DUB)
and
Dynamic Underbalance Post Perforating (DUB-PP)

- DUB-PP evolved from conventional DUB.
- Both create “implosion” in wellbore.
- DUB-PP used anytime after the actual perforations established
- DUB-PP required for lower pressure environment.



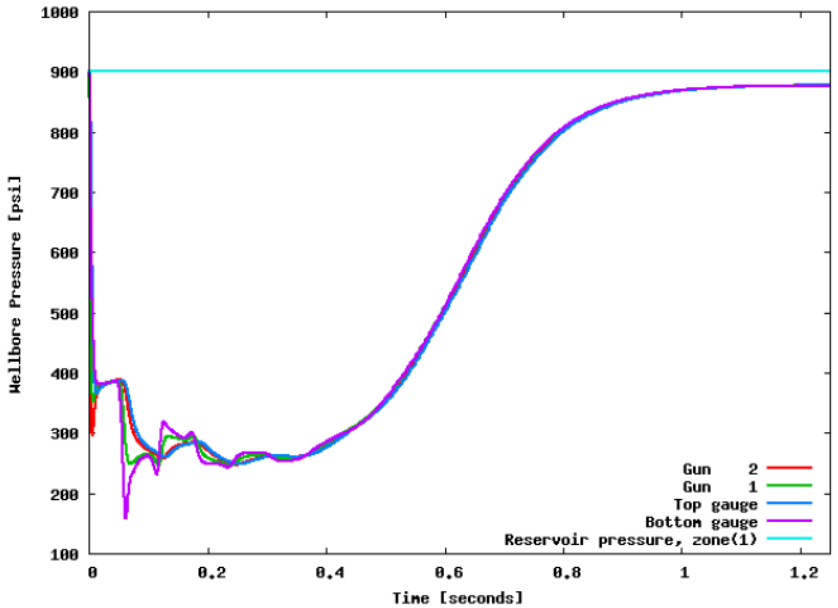
Well Candidates

Well	Casing Size	Perforation History	Perforating Plan	DUB-PP Plan
Well A	7-in.	Previously perforated with 4.5-in. 5-spf guns	Reperforate existing interval with 4.5-in, 5-spf guns	4.5-in. DUB-PP guns
Well B	7-in.	Previously perforated with 4.5-in. 5-spf reactive liner charges followed by 3.375-in. propellant system	Not applied	4.5-in. DUB-PP guns
Well C	4.5-in.	Previously perforated with 2.875-in, 5-spf reactive liner charges followed by 3.375-in. propellant system	Not applied	2.875-in. DUB-PP guns

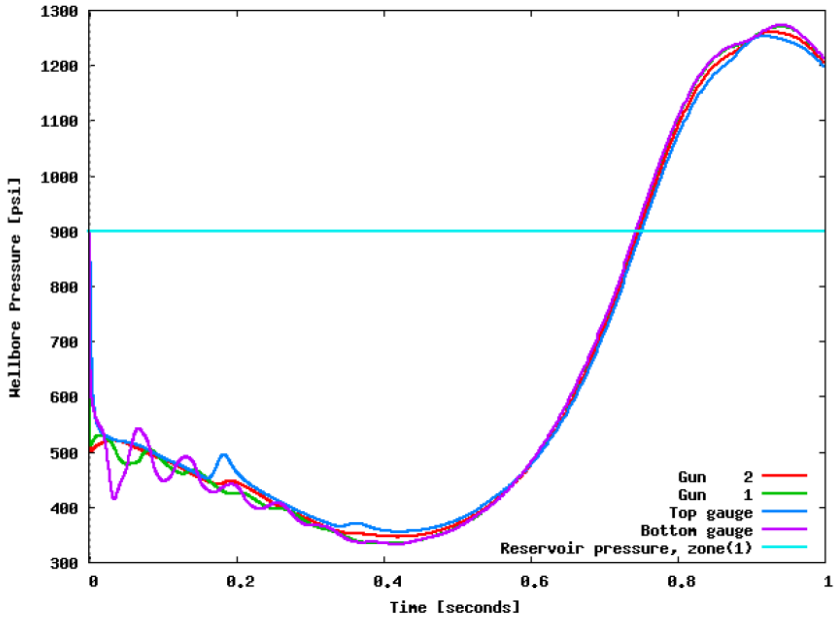
- Start operation with Well-B and C, followed by Well-A later.
- Reperforation not planned for Well-B and Well-C.

Well-B and Well-C Operations

Pre-Job Simulation



Well B prejob DUB-PP dynamic underbalance simulation output.

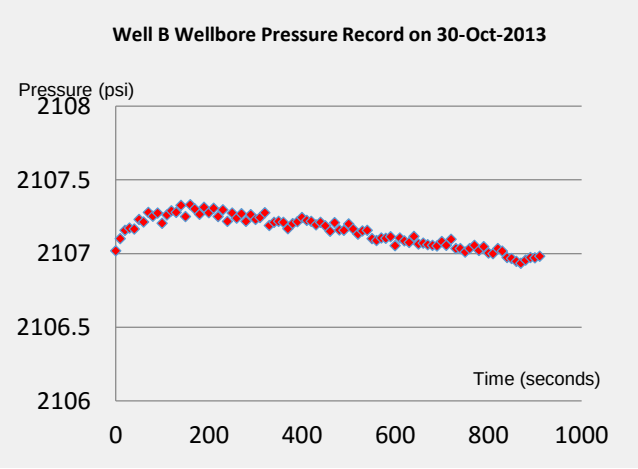


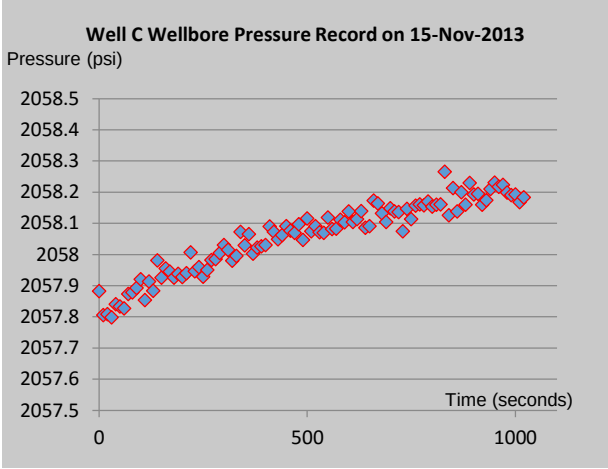
Well C prejob DUB-PP dynamic underbalance simulation output.

- DUB-PP gun designed based on simulation.
- Reservoir pressure expected to be about 900-psi

Operations

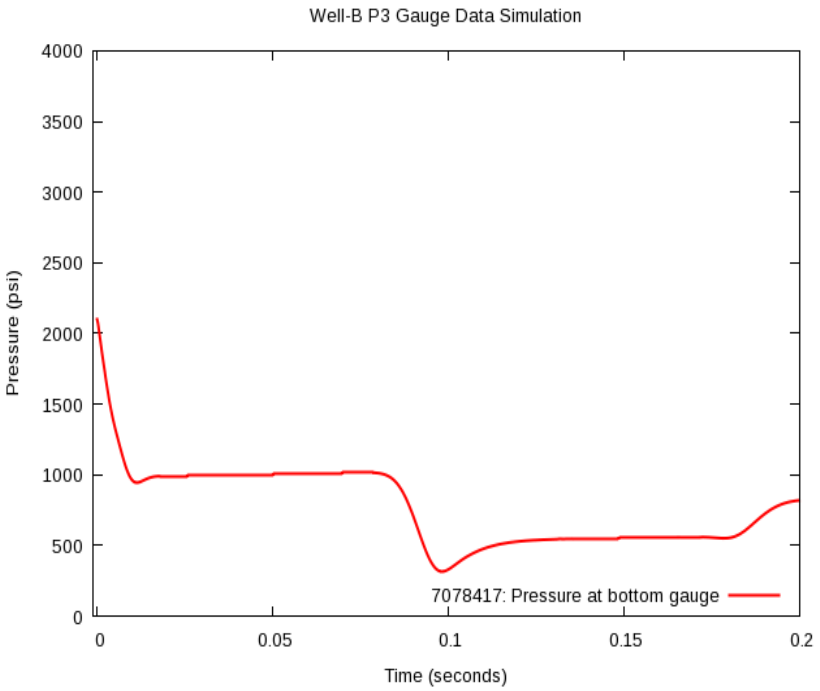
- Stop well injection 2-days before the actual operation.
- Run pressure survey to confirm wellbore pressure stability.

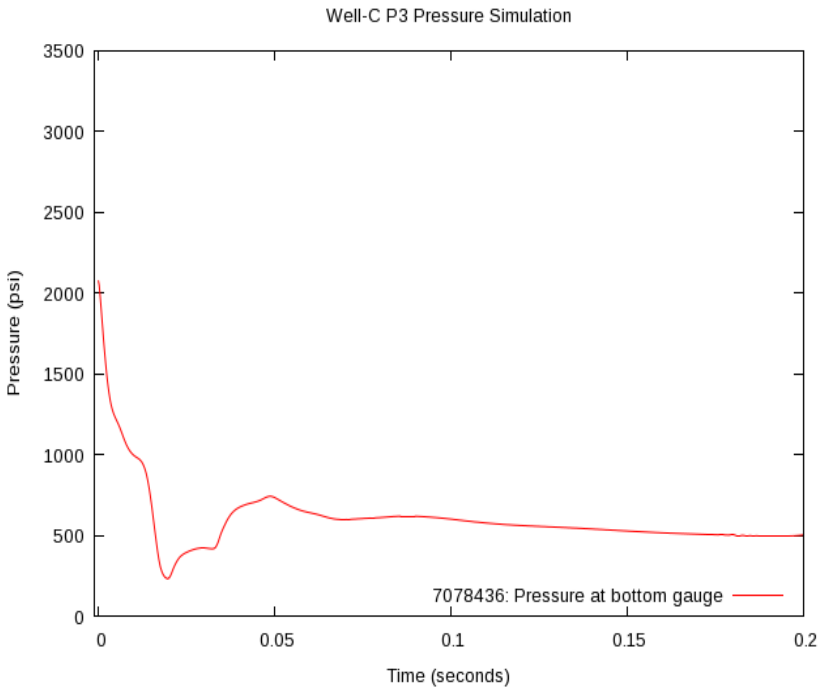




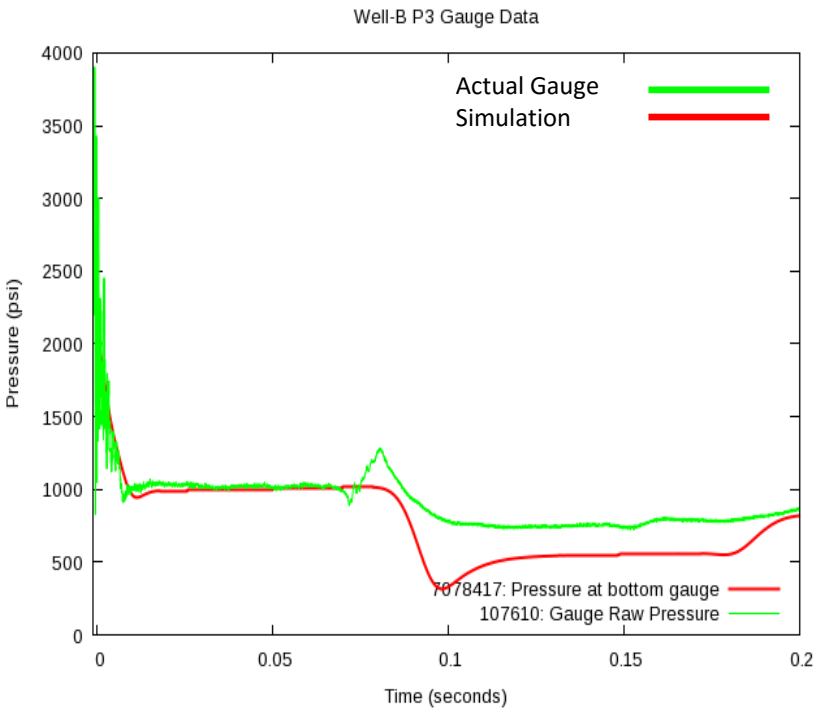
- Re-run the pre-job simulation based on new pressures.
- Run DUB-PP guns together with fast-recording-pressure-gauge to record DUB event.

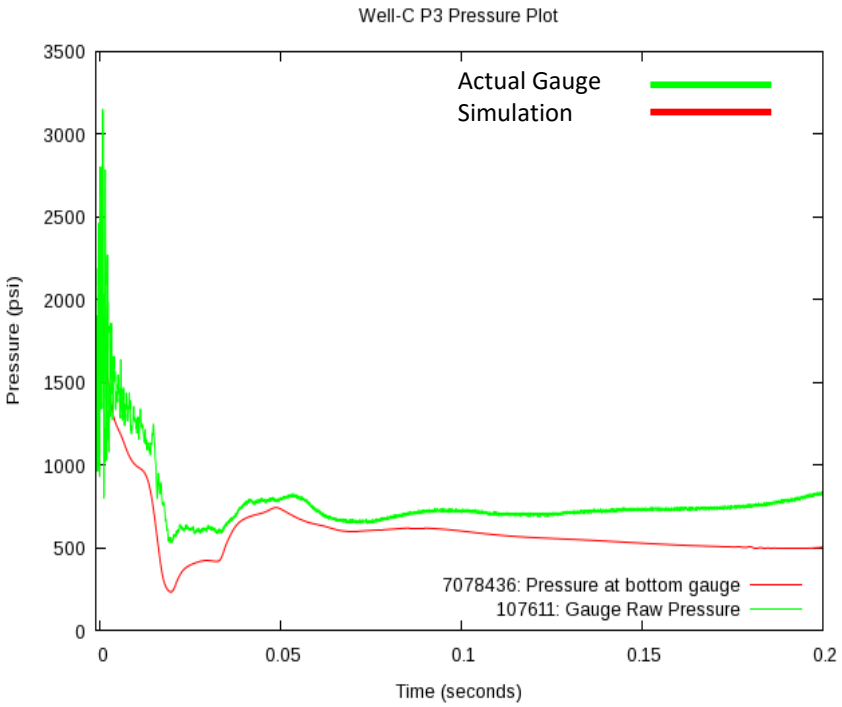
Pre-Job Simulation – Based on Actual Well Pressure





Operations – Post Job





- DUB achieved.
- Gauge data compares well to simulation

Post Job Well Performance

Date	Events on Well-B	Reservoir Pressure (psi)	Injection Pressure (psi)	Injection Rate (litres/minute)	Injectivity (Litres per day/psi)
Jan-13	Perforating using Reactive Liner followed with propellant	900	Not Tested		
Feb-13	Welltesting using dedicated well test unit	900	1150	2.2	1.4
Nov-13	Wellbore Implosion using DUB-PP system	2112	Not Tested		
Jan-14	Welltesting using dedicated well test unit	2112	1250	53	64.4

Date	Events on Well-C	Reservoir Pressure (psi)	Injection Pressure (psi)	Injection Rate (litres/minute)	Injectivity (Litres per day/psi)
Dec-12	Perforating using Reactive Liner followed with propellant	900	Not Tested		
Jan-13	Welltesting using dedicated well test unit	900	1250	1.9	1.1
Nov-13	Wellbore Implosion using DUB-PP system	2075	Not Tested		
Jan-14	Welltesting using dedicated well test unit	2075	1250	53	62.5

Well-A Operations

Well	Casing Size	Perforation History	Perforating Plan	DUB-PP Plan
Well A	7-in.	Previously perforated with 4.5-in. 5-spf guns	Reperforate existing interval with 4.5-in, 5-spf guns	4.5-in. DUB-PP guns
Well B	7-in.	Previously perforated with 4.5-in. 5-spf reactive liner charges followed by 3.375-in. propellant system	Not applied	4.5-in. DUB-PP guns
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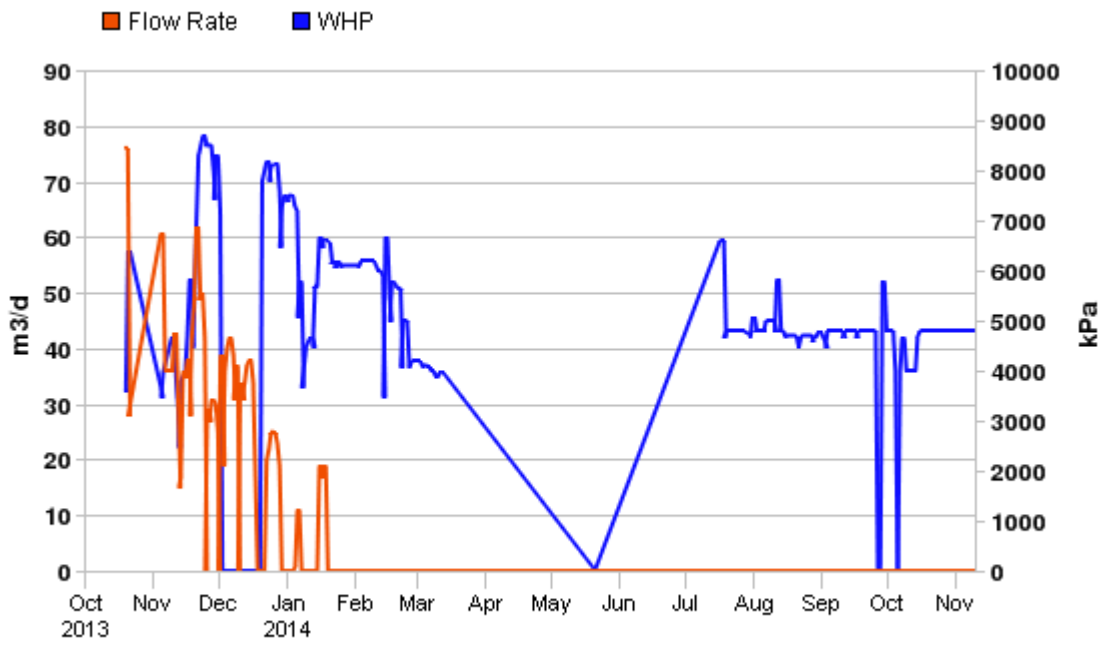
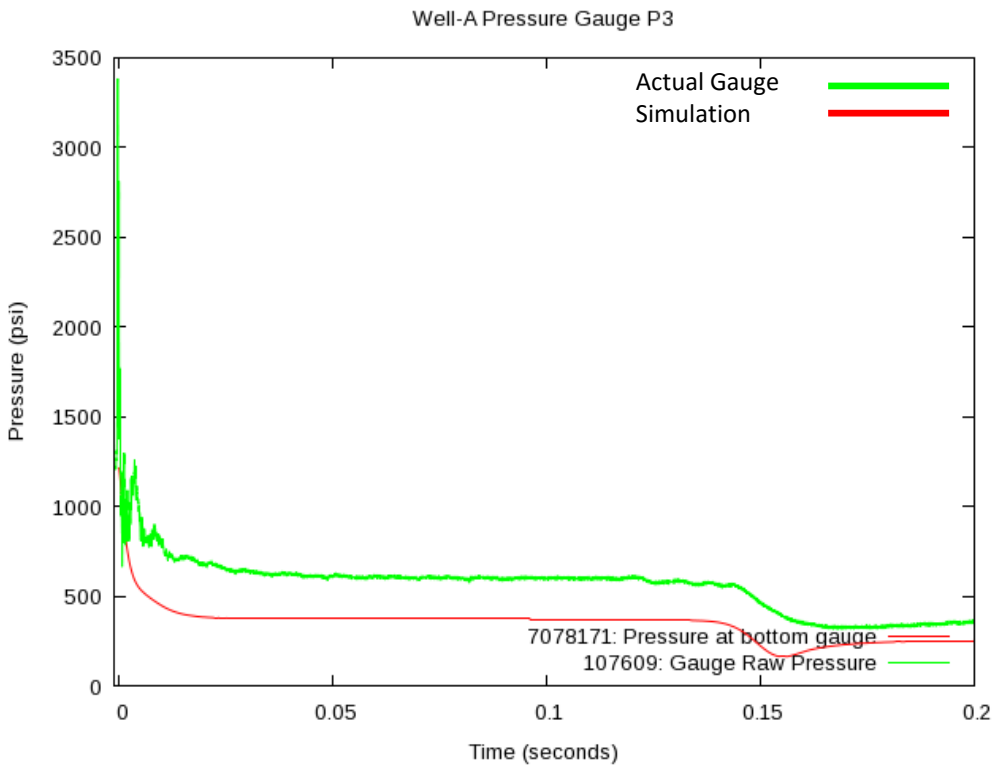
Well-A Plan



Well A historical injection performance prior to the reperforation and DUB-PP job.

- To reperforate followed by DUB-PP
- Job sequence similar to previous two wells

Well-A Post Job Analysis



- DUB achieved but well injectivity did not improve.
- Neither reperforation nor DUB-PP effective.

Conclusion

- Wellbore implosion using the DUB-PP technique successfully improved injectivity of two water injector wells in the low to medium reservoir pressure range.

- Standard perforating or DUB-PP could not overcome well with suspected water-rock compatibility problem.

QUESTIONS?
THANK YOU!