Extreme Overbalance Perforation

[EOP]

AIMING FOR IMPROVING WATER INJECTION WELL INJECTIVITY

AND MINIMIZING NON COMFORMANCE ISSUE

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Agenda

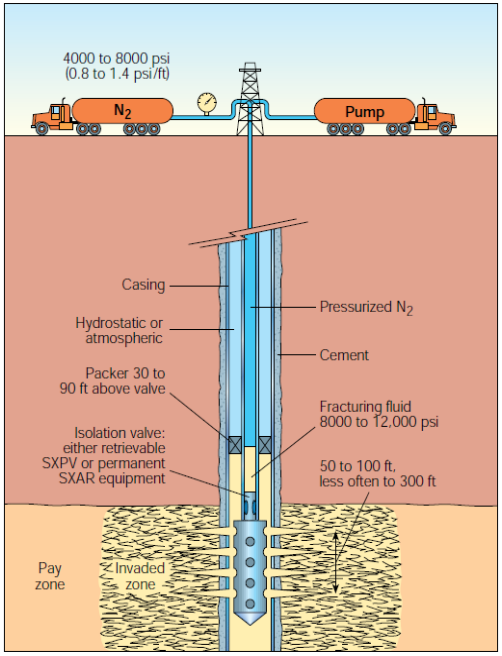
- What is EOP
  - How it works
  - Main benefits
- Reservoir / Formation Background
- Field Trails: (Issue, execution, results)
  - Field Case Well-1
  - Field Case Well-2
  - Field Case Well-3 (*Comparison HF vs. EOP*)
- Conclusion & Away forward

(EOP) Extreme Overbalance Perforation

- **Definition:**
  - Perforating above formation fracture gradient pressure.
- **Main benefits:**
  - Create better conductive path between the reservoir and Well bore.
  - Go beyond expected damaged zone.
  - Cheaper and more effective that HF.
- **How its Work**
  - Run perforation guns to the depth of interest
  - Spot to the top of the gun small amount of liquid selected (brine, solvent, acid, frac fluid) – partial cushions
  - Then the string will be filled with compressible gas - Nitrogen
  - The gas column is then pressured up typically at about 4000 PSI (28000 kPa)
  - With detonation of the guns, the liquid is driven at very high flow rates by the rapidly expanding gas N2 and rushes into the perforation
  - Because the liquid is nearly incompressible, it acts as a wedge that initiates fractures, extending the effective wellbore radius
  - The EOP pressure gradient usually needs 1.4 psi/ft or 31.6 kPa/m.

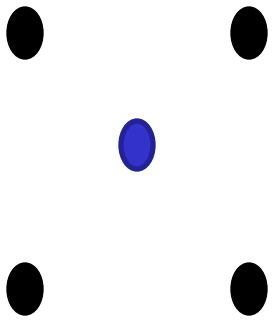
What is

- **EOP**
- **Main Benefits**
- **How its Work**



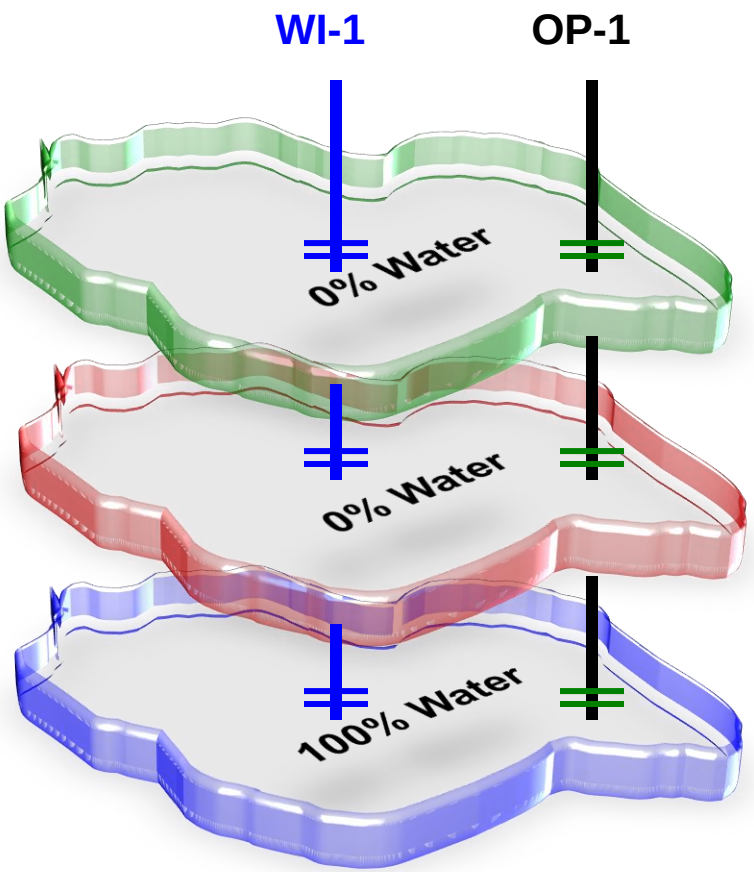
Reservoir / Formation Background

- Injection and Production from Upper, Middle and Lower Gharif
  - Stacked channel sands of alluvial plain deposits intercalated w/ silts and clays
- Surrounding oil producing wells (5 Spot pattern)
  - High permeability sands up to 4 D and 25% porosity
  - 30 API (0.876 g/cc), Oil viscosity 13 cp
- Low reservoir pressure and temperature
  - 10,000 kPa (1,450 psia)
  - 65 deg C (149 deg F)
- Wells depict positive skin damage in general.
- Very weak aquifer support.
- Secondary drive is required immediately once production commenced



Field Trails: (Issue, execution, results)

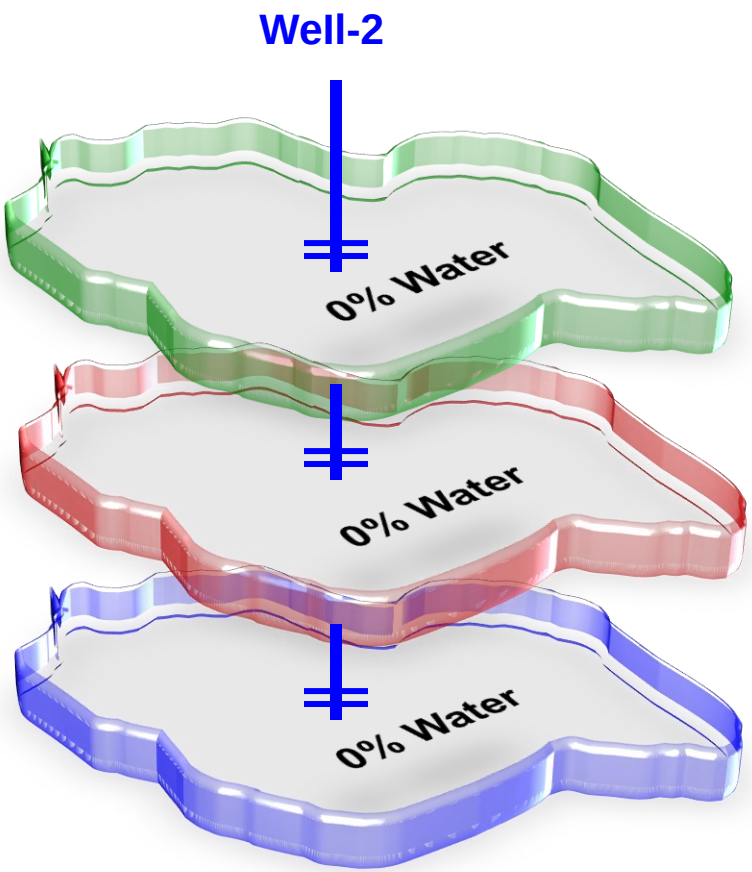
Well-1:



- **Main Issue: <u>non conformance</u>**
  - MPLT indicate water only goes lower layer
- **Execution:**
  - Re-perforate the upper zones layer with EOB Perforation
  - 4.5” HSD gun loaded w/ 5 SPF PJO 4505 HMX charges was run on 3-1/2” DP
  - The execution went well and no safety and environment issue.
- **Results:**
  - Injection profile improved resulted to better sweep efficiency and increase Gross of nearby OP-1 to +24% and net oil by +34%

Field Trails: (Issue, execution, results)

Well-2:



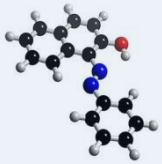
- **Issue: Zero injection.**
  - New well, completed initially with common perforation system PJ 4505,5 spf.
  - Perforation ceased after a month period.
- **Execution:**
  - Acid was first spotted across the perforation
  - Re-perforate all layers together with EOB Perforation+ solvent compensation.
  - 4.5” HSD gun loaded w/ 5 SPF PJ 4505 HMX charges was run on 3-1/2” DP
- **Results:**
  - Injection profile improved and injection reestablished for all layer

Well-2: *Solvent Spot & Extreme Overbalance Perforation* Result

1

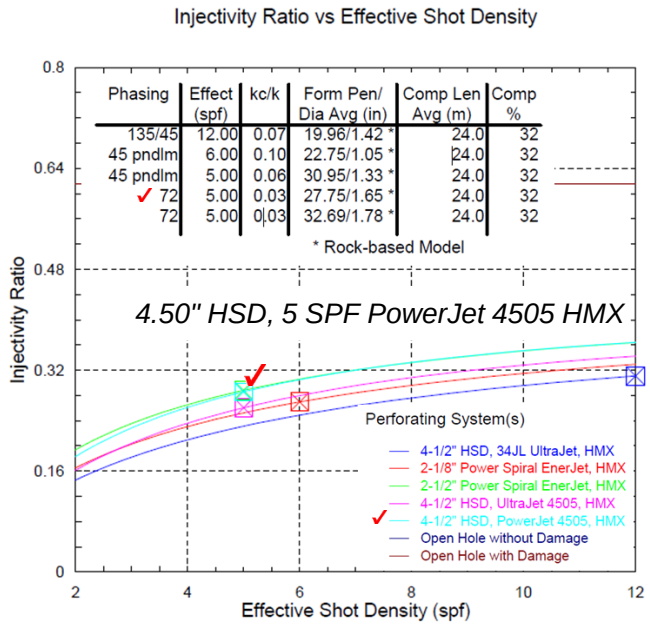
Spot solvent

Aromatic and Mutual Solvent with Surfactant



2

Perf selection EOP



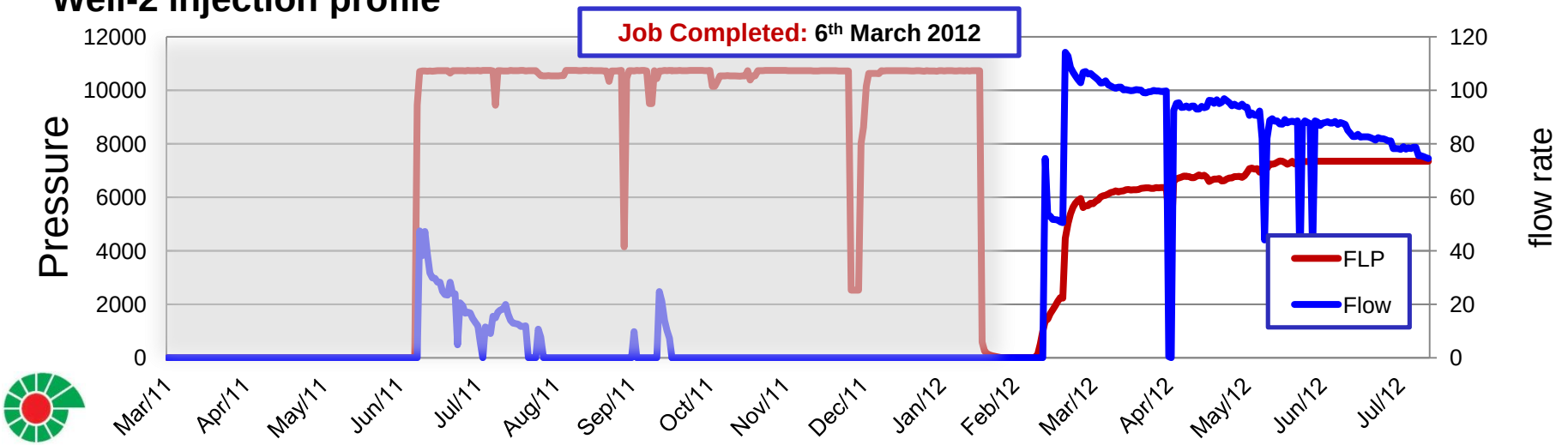
Injectivity test

(Based on 5000 kPa injection pressure)

Reservoir	Rate (m3/day)
Layer 1	**40**
Layer 2	**120**
Layer 3	**526**

5 times +
injection target

Well-2 injection profile



Comparison HF vs. EOP (Field Case Well-3)

Well-3 (WI)

- Prop Hydraulic Fracturing was performed.
- Injectivity has been improved and dropped to pervious level few weeks after Fracturing due to flowback proppant.

Hydraulic Fracturing	EOP
Expensive	cheaper
Flowback proppant risk.	No risk, except controlling N2 high pressure.
Risk of getting bearkthough water shortcut	Minimum risk of water breakthough.

Conclusion & Away forward

- EOP work effectively to reduce the non conformance injection.
- The injection after extreme overbalance was decent from zero injection to ~400 m3/d at low surface inj. pressure of 5,000 kPa.
- Extreme over balance perforating technique has been proven successfully and it could replaced HF on some wells conditions.
- Methodology/ technique can be applied to the other wells in different fields
- Heading to Complete 3 more trials at the same areas.
- Continue evaluate the results by PLT and calculate the oil gain
- Continue using solvent spot combine with EOP in Water Injectors
- Evaluate this method to apply it in our producer wells
- Evaluate to combine this method with acid stimulation.

Thank you

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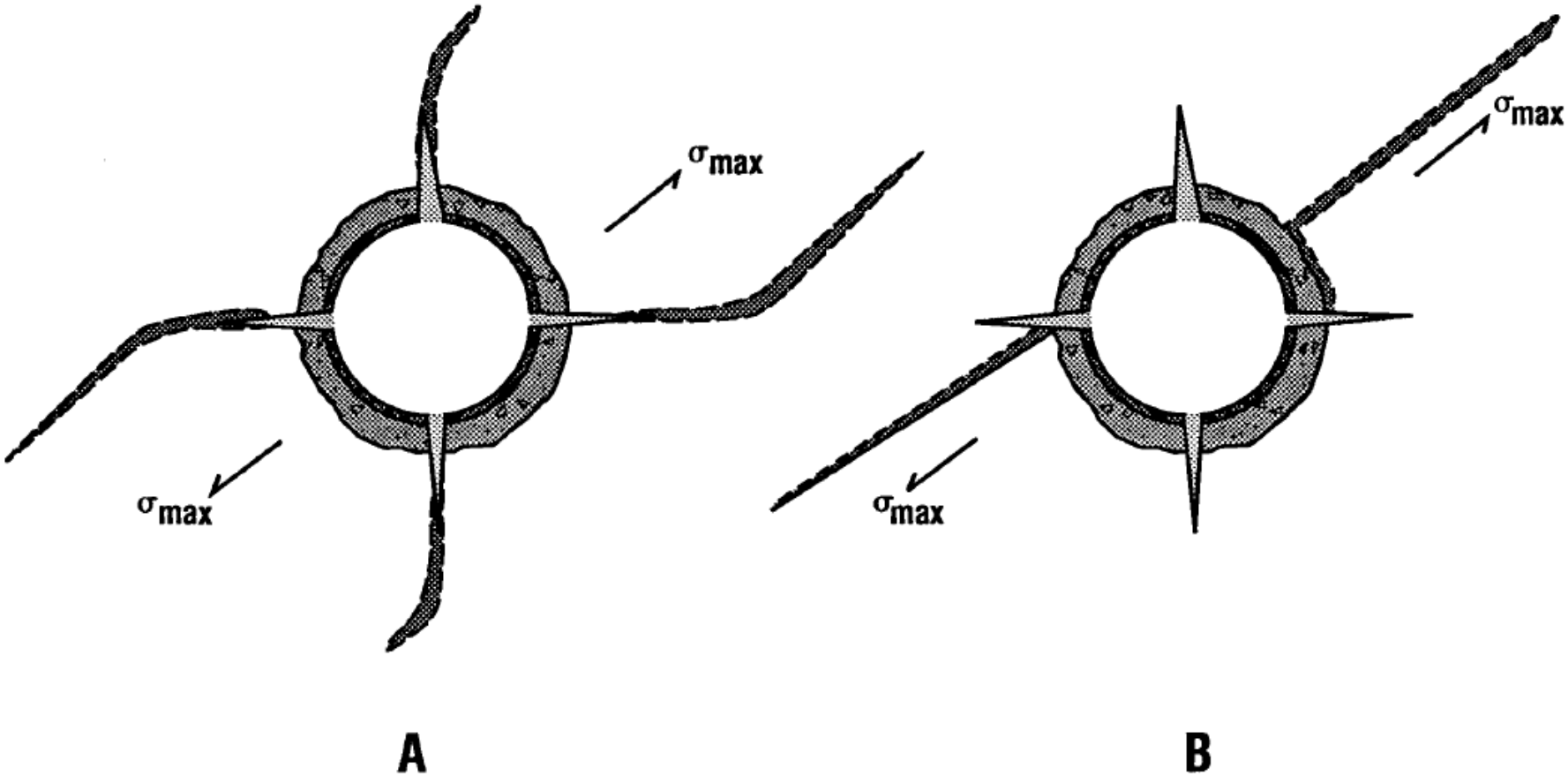
Back up

Fracture Orientations EOP vs. Underbalanced Perforations



Extreme Overbalance

Statically Underbalanced Perforations

SPE 26515

Details Operational Procedure (Well-2)

- A liquid head/ solvent was first spotted in the zone of interest
- Tubing conveyed guns were then run in hole with brine of 3500 kPa (~ 340 met.)
- Depths were correlated w/ WL GR/CCL and TCP guns were spaced out
- Packer was set mechanically and pressure tested
- through annulus to 5000 Kpa for 15 mins. and correlation has been double checked
- Bled annulus to 1000 Kpa and held this pressure for gun firing
- Surface pump was rigged up and all surface lines were pressure tested
- Nitrogen was pumped down the tubing to generate sufficient pressure
- 4000 psia was set as the shear pressure for HDF (hydraulic firing head)
- 800 gallons of N_2 was injected and surface pressure has been built up to 4000 psia
- The guns were fired at 27600 Kpa (4000 psia) surface pressure
- A bottom hole gradient about 23 Kpa/ meter has been achieved
- HDF Delay time was set to be around 5 mins with 4000 psia N2 pres.
- Waited 15 mins while observing THP for stability
- Opened packer bypass and reverse circulated and checked the flow
- Unset the packer once well is stable and checked the flow to confirm
- Pulled out of the hole
- Run in hole again for selective injection test for individual zones
- Performed selective injectivity tests by isolating individual zones