CUSTOMIZED DYNAMIC UNDERBALANCE PERFORATIONS YIELD MUCH HIGHER PRODUCTIVITIES THAN CONVENTIONAL PERFORATIONS: CASE STUDIES FROM EAST VENEZUELA

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Challenge:

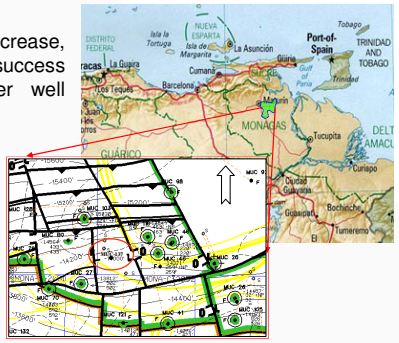
In the North-East of Venezuela, Punta de Mata fields, wells recompleted during Workover interventions yielded unsatisfactory production results due to severe near wellbore damage:

- High formation damage induced by drilling and workover fluids invasion.
- High heterogeneity, multi-layers field
- Asphaltene flocculation.
- Fines migration intensified by high production drawdown pressure.

Additional Challenge:

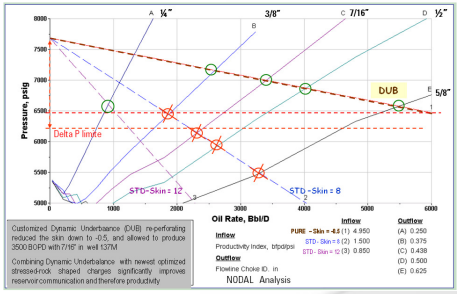
As the field and reservoirs complexity increase, conventional techniques have resulted in limited success in many cases failing to increase or recover well production:

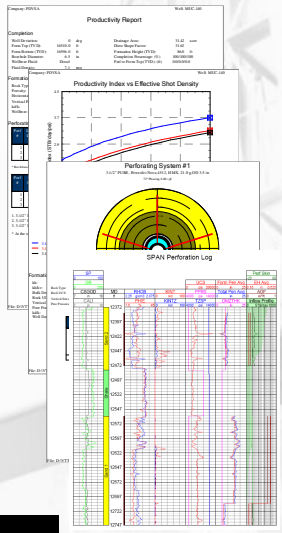
- Standard re-perforating jobs without success
- Matrix Stimulation with limited results
- Coil tubing clean up without good results

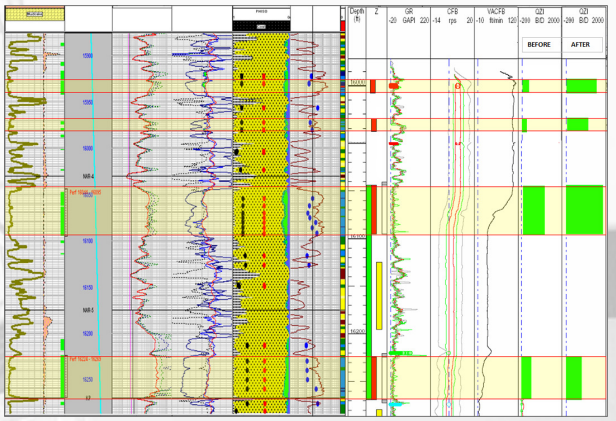


Analysis:

- Mechanical: completion integrity.
- Petrophysics analysis per interval
- Dynamic: Multirate tests, Production Logs and Build-up transient tests. NODAL analysis.
- Wellbore damage-skin characterization and evaluation per interval. Perforating analysis.







1. Comprehensive analysis of previous unsuccessful stimulations, perforating and re-perforating interventions .
2. Detailed production logs review for production impeachment analysis interval per interval, comparing Ideal PI vs actual PI.
3. NODAL and Perforating analysis to select re-perforating systems per interval.

Solution:

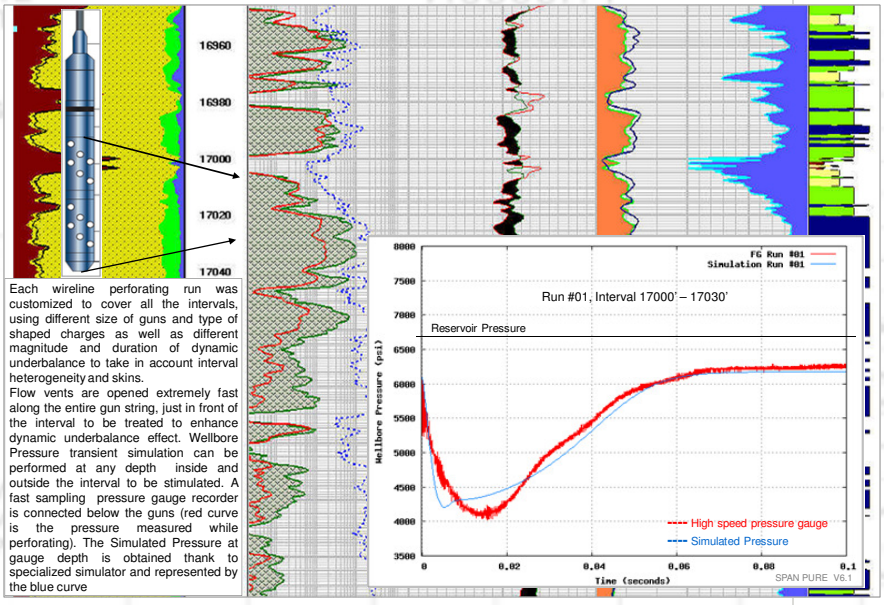
A tailored wireline Dynamic Underbalance Re-perforating:

- Customized for each interval to treat.
- Using controlled and focused dynamic under balance, for effective removal of near wellbore formation and perforating damages.
- Designed with specialized Simulator and Hardware.
- Combined with new ultra-deep penetrating shaped charges, specially designed for stressed-rock performance.
- Perforating systems (gun size, charge type, shot density) selected to optimize flow profile and well productivity.

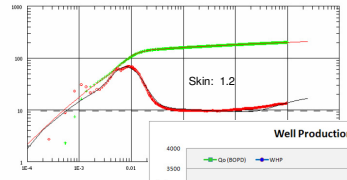
Well Interventions Results

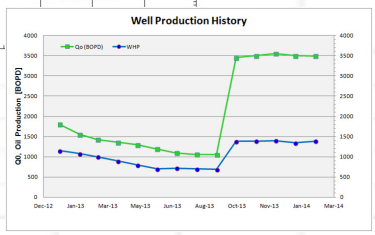
Well	Qo Before BOPD	Qo After BOPD	Delta Qo BOPD	Production Increment %	Production Results	Skin Before	Skin After	Qo Expected BOPD	Re-perforated Gun design
W-1	335	4100	3765	1124%	1224%	73	1.2	950	2" DUB, PJN and P3
W-2	1050	3500	2450	233%	333%	41	-1.0	1450	2 7/8" DUB, PJO,PJN
W-3	550	4500	3950	718%	818%	44	0.5	1200	2" DUB, PJN and P3
W-4	1200	5400	4200	350%	450%	59	-0.5	2200	2 7/8" and 3 3/8" DUB, PJN

DUB: Dynamic Underbalance Re-perforating. P3: Dynamic Implosion Stimulation. PJN new optimized stressed-rock shaped charges. PJO previous deep penetraiting shaped charges.



Each wireline perforating run was customized to cover all the intervals, using different size of guns and type of shaped charges as well as different magnitude and duration of dynamic underbalance to take in account interval heterogeneity and skins.
Flow vents are opened extremely fast along the entire gun string, just in front of the interval to be treated to enhance dynamic underbalance effect. Wellbore Pressure transient simulation can be performed at any depth inside and outside the interval to be stimulated. A fast sampling pressure gauge recorder is connected below the guns (red curve is the pressure measured while perforating). The Simulated Pressure at gauge depth is obtained thank to specialized simulator and represented by the blue curve





Results:

The results obtained under such challenging conditions prove that the technique of Dynamic Underbalanced Re-perforating:

- Is very effective in removing severe formation and perforating induced damages.
- Delivers skinless perforated completions.
- More than triples well production.
- Cost effective intervention.