CASE STUDY – MANAGED PRESSURE DRILLING

Managed Pressure Drilling approach to Completion String and Run Design in West Africa

Challenge

Narrow annular clearances, numerous Sand Screen System components, and sensitive Reservoir Isolation Valves made completion runs vulnerable to surge pressures offshore the Ivory Coast.

Figure 1: Offshore West Africa (the Ivory Coast)

The difficulties were broken down into four operations:

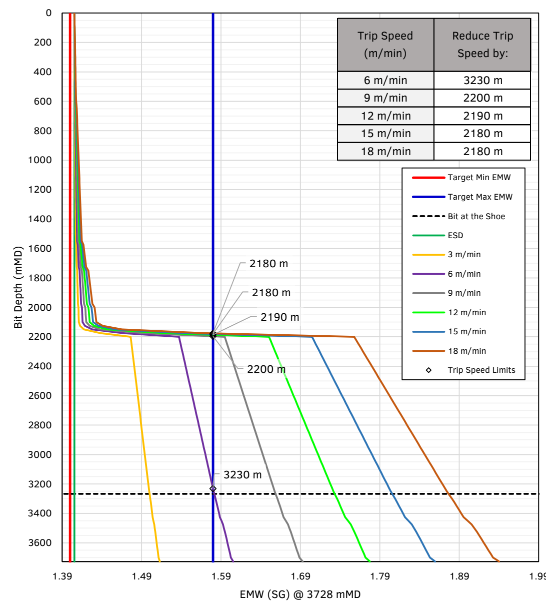
1) Excessive Surge Pressures while running the Lower Completions String into the Open Hole
2) Maintaining the wellbore EMW while the Completion/Activation fluid was circulated into place (preventing U-tubing)
3) Excessive Pressures during WBCO (Wellbore Cleanup Operations) triggering the Reservoir Isolation Device
    a. Thru-tubing runs into the LC String
    b. Thru-tubing fluid displacement within the LC String

Solution & Methodology

The respective MPD approaches to the problems described are:

1) Develop a Surge Analysis with as high-resolution input as possible by
    a) Running an Open Hole caliper log to parse the open hole into multiple averaged sections rather than just the bit size in the modeling software.
    b) Break the completion string into as many sub-components as possible and similarly parse the items into the string input.

Figure 2: Completion String Surge Analysis – EMW Observed at Multiple RIH Speeds



2) The MPD System was used to prevent excessive displacement of the spacers and activation fluid while maintaining SBP once the placement was completed. This action prevented fluid U-tubing until the top packer was successfully set.

3) a) When thru-tubing is run into the string – causing surge pressures

Figure 3: WBCO – Thru-Tubing Run Internally into LC String

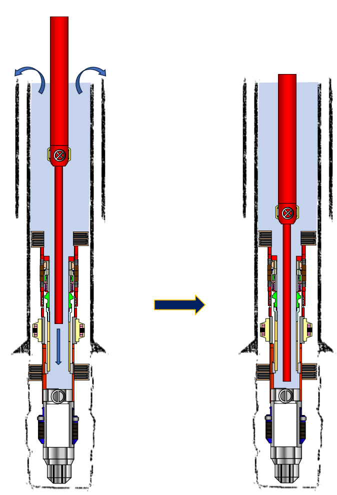


Figure 4: Thru-tubing String Surge Analysis – EMW Observed at Reservoir Isolation Device(s)

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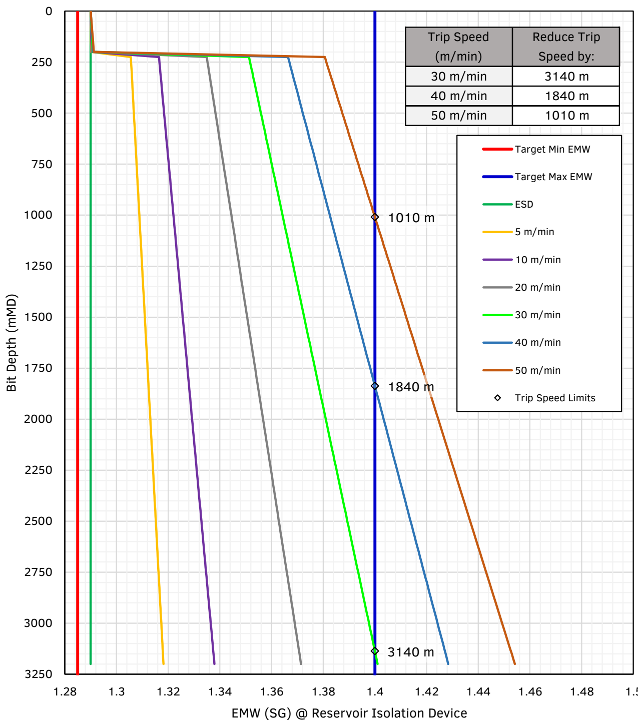


Modeling the surge pressures was conducted by detailing the IDs of the LC string as the new 'wellbore,' and the Thru-Tubing string was used as the new string run-in hole for the surge analysis.

b) When WBCO pills are circulated – causing 'inner' annular frictional pressures.

Figure 5: WBCO – Thru-Tubing Fluid Displacement – Well Diagram

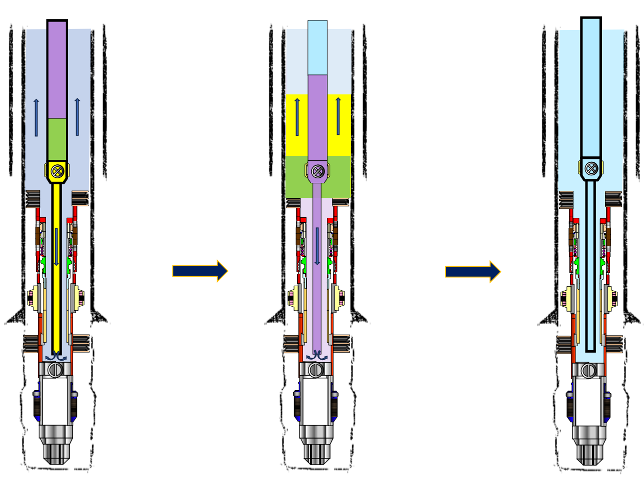
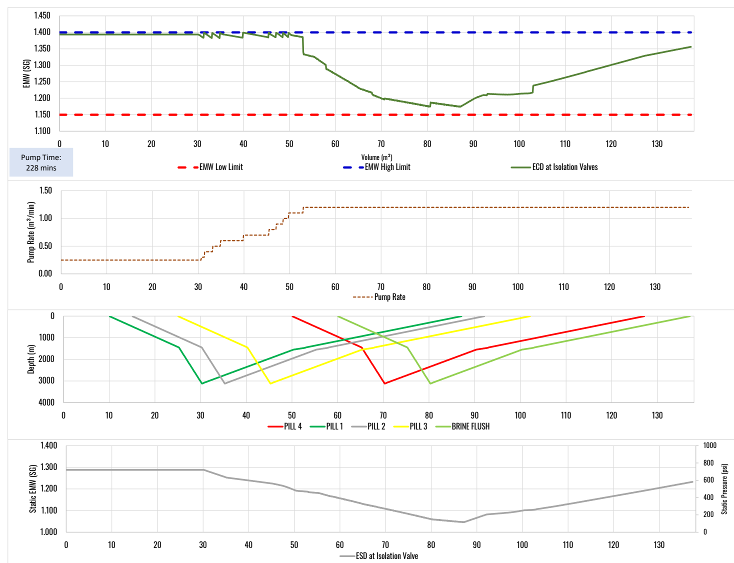


Figure 6: WBCO – Thru-Tubing Fluid Displacement – Displacement Schedule

MULTI COMPLETION PILL DISPLACEMENT VIA THRU TUBING

Cumulative Volume (m³)	Flow Rate (m³/min)	Dynamic SBP (psi)	Static SBP (psi)	ECD @ TD (SG)	ECD @ 3126m (SG)	Accum. Vol. (m³)	Comments (Assumed Stroke Capacity = 0.014 m³/stk @ 97%)
0.0	0.25	0	0	1.400	1.395	0.0	Start pumping 1.23 SG Brine
15.0	0.25	0	0	1.400	1.400	15.0	Pump 1.1 SG fluid at 15 m³
25.0	0.25	0	0	1.400	1.400	25.0	Pump 1.03 SG fluid at 25 m³
30.0	0.25	0	0	1.400	1.400	30.3	0.81 SG Fluid turns the bit at 30 m³
30.6	0.30	0	0	1.390	1.390	30.6	Increase flowrate to 0.3 m³/min at 30.6 m³
31.3	0.40	0	0	1.400	1.400	31.3	Increase flowrate to 0.4 m³/min at 31.3 m³
33.1	0.50	0	50	1.400	1.399	33.1	Increase flowrate to 0.5 m³/min at 33.1 m³
34.8	0.60	0	80	1.400	1.400	34.8	Increase flowrate to 0.6 m³/min at 34.8 m³
35.0	0.60	0	90	1.400	1.400	35.3	1.1 SG Fluid turns the bit at 35 m³
39.8	0.70	0	130	1.400	1.400	39.8	Increase flowrate to 0.7 m³/min at 39.8 m³
45.0	0.70	0	180	1.390	1.390	45.3	1.03 SG Fluid turns the bit at 45 m³
45.4	0.80	0	180	1.400	1.400	45.4	Increase flowrate to 0.8 m³/min at 45.4 m³
47.0	0.90	0	200	1.400	1.400	47.0	Increase flowrate to 0.9 m³/min at 47 m³
48.5	1.00	0	230	1.400	1.399	48.5	Increase flowrate to 1 m³/min at 48.5 m³
49.7	1.10	0	260	1.400	1.400	49.7	Increase flowrate to 1.1 m³/min at 49.7 m³
50.0	1.10	0	270	1.400	1.400	50.0	Pump 1.03 SG fluid at 50 m³
52.9	1.20	0	300	1.350	1.342	52.9	Increase flowrate to 1.2 m³/min at 52.9 m³
60.0	1.20	0	390	1.280	1.280	60.0	Pump 1.23 SG fluid at 60 m³
70.0	1.20	0	550	1.200	1.200	70.3	1.03 SG Fluid turns the bit at 70 m³
80.0	1.20	0	700	1.180	1.180	80.3	1.23 SG Fluid turns the bit at 80 m³
114.4	1.20	10	430	1.290	1.281	114.4	Increase SBP to 10 psi at 114.4 m³
137.3	1.20	10	160	1.360	1.357	137.3	Brine to surface at 137.3 m³



During the WBCO, once the thru-tubing was in place, the circulation of multiple completion pills was at risk of prematurely triggering the Reservoir Isolation Valve(s). MPD hydraulics determined the optimal pumping schedule to position the pills without exceeding the high-pressure limits, specifically at the Isolation Device(s) in place.

The fluid displacement EMW was regulated by adjusting the pump rate to remain within the critical pressure window, specifically below the Isolation Valve trigger pressure

Results & Conclusion

1. The utilization and involvement of MPD hydraulics early in the planning phase of the drilling and completions was critical to the success of these operations. The most significant benefit is seen when MPD hydraulics modeling can communicate in a feedback loop with the Completions team to develop the completions string for the anticipated pressure window.

2. Tight annular clearances critically and disproportionally affect the pressures experienced downhole during pipe movement (surging) and fluid circulation (annular friction). Therefore, in order to accurately assess these anticipated pressures, quality input is critical for precise output. Running an open-hole caliper log and precisely measuring the LC string components and through-tubing strings was critical to these analyses and is highly recommended.

3. The entire MPD program was designed with a focus on the lower completions string run. The main objective was to eliminate wellbore instability during drilling, connections, tripping, and running in. With these factors in mind, completion of NPT was avoided entirely when MPD analyses were brought in.

4. MPD surge analyses improved the decision-making process regarding the LC string. This allowed for maximizing the number of crucial sand screen system components to be included, which benefited the production performance of the wells.

5. MPD fluid displacement analyses and follow-through to execution were able to mitigate the risk of incidental triggering of internal pressure-activated valves safely.

References

MPD Approach to Completion String Design and Run Enabled Operator to Successfully Complete Wells in Highly-Unstable Formations Offshore West Africa

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