



Mitigating Exploitation Challenges in Unconventional HPHT Development Field in KG Offshore Basin

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Summary

“Deen Dayal West Field” (DDW) is a HPHT tight gas field comprising of multilayered fluvial sandstone reservoirs of Lower Cretaceous Age. Within the period of trial production from two wells completed in these multilayered reservoirs, two main challenges surfaced viz. (1) Leakage in production tubing in well-A & (2) sharp fall in production in well-B. Trouble shooting through PLT posed another challenge as it required High Pressure - High Temperature PLT (HPLT) tool with H₂S / CO₂ resistant mono core cable having sufficient breaking strength to log at a depth of 5300 m¹ within safe pulling limit. Present paper details the process in mitigating the challenges in PLT recording and identification of possible causes which may be addressed during work over planning. This paper discussed elaborately about the problems faced in PLT logging, the way out to handle these adverse conditions and bring out remedial measures for the sick wells.

Introduction

DDW field is located in Krishna Godavari (KG) Basin in Bay of Bengal, Eastern coast of India and is operated by GSPC. The field is presently in development stage and under trial production. The wells are drilled to a depth of 5300 m in hostile HPHT conditions where the reservoir temperature is around 390-400°F and pressure is around 11,500 psi. Moreover, wells are producing hazardous H₂S and CO₂ gas. The wells have encountered multilayered tight Sandstone reservoirs of Lower Cretaceous age with permeability ranging between 0.01 - 1 mD and gross reservoir thickness extending to 550-650 m.

Wells are generally completed in multilayer with commingled flow.

Test production from two wells i.e. Well-A & -B started around mid 2014 but within short period of 4-5 months, there was a drop in production in both the wells. Also, problem with completion integrity in Well-A was noticed as there was increased pressure in the annulus. All the indirect studies in Well-A pointed to a possible Tubing Leakage.

Methodology

The job required appropriate planning and execution of PLT logging to (1) identify leakage point in Well-A & (2) assessing layer wise production profiles in both the wells. Subsequent remedial follow up jobs were carried out based on PLT findings.

Major hurdles in carrying out PLT job in DDW field are:

- (i) Non availability of high temperature PLT tool (HPLT) which can work at 390°F for sufficient long hours of recording.
- (ii) Requirement of H₂S & CO₂ compliance mono core cable which should have sufficient safe breaking limit to log at 5300 m.
- (iii) Service provider (M/s SASL²) also did not have previous experience of recording PLT in such a hostile environment in India. Whatever PLT jobs previously done in India in HPHT conditions were carried out in wells of much shallower depth and therefore, tool was exposed to HT for lesser time.

¹ All depths mentioned in this paper are Measured Depths (MD)

² M/s Schlumberger Asia Services Ltd.

Overcoming the problems:

After several rounds of technical discussions, SASL arranged a PLT tool encapsulated in a flask enabling it to work around 390°F. Necessary equipments viz. H₂S - CO₂ compliant cable, 15K pressure control equipment were in place to handle adverse well condition. Micro planning considering all timings of every activities viz. lowering & pulling out, flow stabilization etc. was a key for successful accomplishment of the job. "PLT on Paper" exercise was carried out in coordination with SASL Engineers.

First job was attempted in well-A and the job sequences are as follows;

- Temperature & Pressure tools were stacked along with Dummy in the first run to assess bottom hole pressure & temperature before running HPLT tool. Adding these tools with dummy is not a normal practice.
- During lowering dummy tool, recording continued and well was flowing through annulus to burner. It resulted in getting an indication of tubing leakage point and also to record bottom hole Temperature & Pressure profiles up to 5300 m.
- Next run was made with HPLT while the well was flowing through annulus.
- While lowering the tool, tubing leakage points at 1372 m & 1385 m were confirmed.

At 4743 m (i.e. 20 m above the top most perforated interval) the tool was not going down and while pulling up a high tension was observed which was close to the safe pulling limit of the cable. Hence, the tool was pulled out of the hole and the job was suspended at this juncture. Meanwhile during pulling out, the tool failed to work as it exceeded the temperature due to exposure to HT for about 8 hrs.

Lessons Learnt & Preparation for 2nd Well (Well-B):

Following lessons were learnt and provided insight / input for the planning of the job in next well:

- HPLT tool can work for a time limit of 8 hr of exposure in HT condition.

- Gas entry noticed in cable after every run. This is a common phenomenon in high pressure gas wells and it may cause disruption of connection at the cable head. Degassing³ the cable took 8 to 10 hr in between runs.

Based on the previous experience, following steps were taken as a preparation for next job in well-B:

1. SASL brought 2 new cable drums (with a provision of one spare drum) so that cable drums may be swapped instead of waiting long time for degassing. These are H₂S compliant cables and being new, breaking strength will be higher.
2. Pressure greasing of the cables were done thoroughly at their base to minimize gas entry.
3. A new set of HPLT tool was brought for taking up job in well-B.

Following PLT operational sequences were carried out in Well-B:

- Well was taken up for HPLT job and Dummy tool got held up at 4740 m. Therefore, only top 3 or 4 layers could be logged. HPLT tool also got held up at 4740 m.
- Recorded 4 hr Shut-in Passes (1 Down & 1 Up) and then well was opened to flow for 2 hr for stable flow condition.
- Tool malfunctioned after reaching at held up depth and so it was pulled out, checked at surface and re-run again after degassing the cable. This time it went up to 4736 m.
- Recorded 4 hr shut-in down log & up log and shut-in station recording at different depths in casing.
- Flowing Passes, 1 up and 1 down pass at cable speeds of 1800 ft/hr, 2200 ft/hr and 2700 ft/hr were recorded in the interval 4670 m to 4736 m (Figure 3). Because of bad hole condition, higher recording speeds could not be maintained. So, instead of planned speeds of 3600 & 4500 ft/hr, logs were recorded at 2200 ft/hr and 2700 ft/hr.
- Flowing station readings were recorded at different depths.

³Degassing is the process of releasing of entrapped gas in the armor of the cable. Cable head is cut and the cable is submerged in water to monitor gas bubble count. Bubbles should be less than permissible limit which is < 10-15 Bubbles/min.

- Finally, during logging operation, Petrophysicists at site & at base and SASL Engineers actively participated online during entire recording period for instant decision related to quality data acquisition.

Observations

Well-A:

- Tubing leakage was detected at 1372 m & 1385 m (Figure 1).
- Contributing zones were identified qualitatively from temperature log recorded during dummy run.
- Out of ten perforated zones, gas entries are noticed from four zones i.e. Zone-1(4761-4764 m), Zone- 3 (4776-4785 m), Zone-4 (4917-4929 m) & Zone-7 (4977-4980 m)
- Major contribution of gas is from topmost perforation interval i.e. Zone-1

Well-B:

- Obstruction in casing at 4705–4710 m due to scale deposition as revealed from caliper logs (Figure 2)
- Logs could cover only top 3 zones out of 21.
- Flow condition is very unstable as reflected on fluctuation in pressure (Figure 3).
- About 83% of gas contribution is from zones below Zone-3. Also there is some contribution from top zone.
- Sharp drop in production is attributed to blockage of perforated intervals and possible formation damage due to scale deposition (Figure 2 & 4).

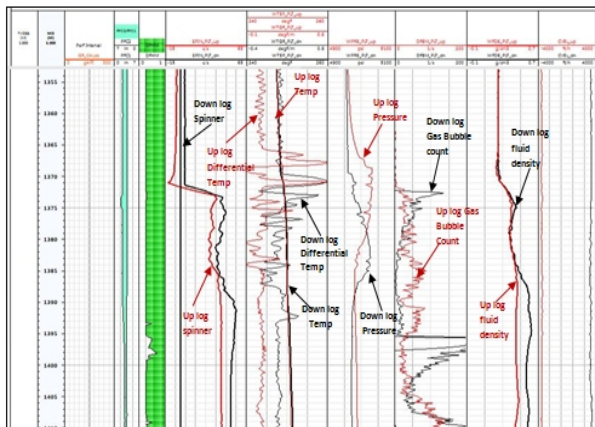


Figure 1: Well-A: Tubing leakage reflected on spinner, Temperature & Fluid Density logs

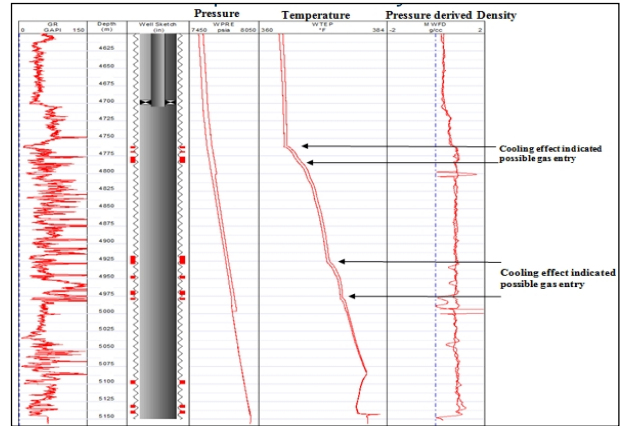


Figure 2: Well-A: Dummy data shows gas entry from 4 zones

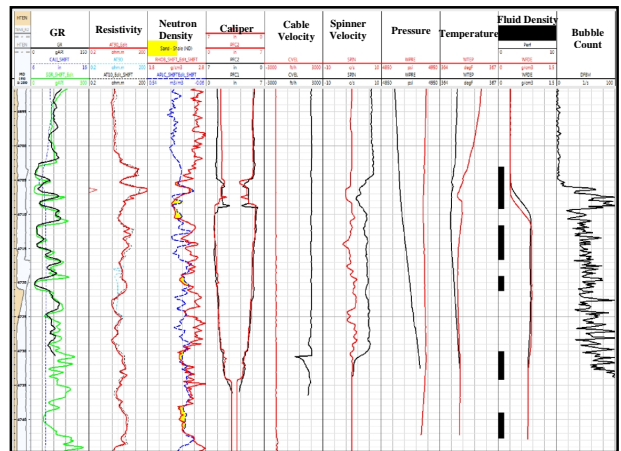


Figure 3: Well-B: Logs of Shut-in passes (Up & Down) at 1800 ft/hr. Obstruction in casing at 4705–4710 m due to scale deposition as revealed from caliper logs

Follow Up Jobs

Well-A: Based on PLT observations, workover job was carried out in the well. The completion string was retrieved, well was cleared, all the zones were re-perforated and recompleted in single string. Well was put back to production.

Well-B: Subsequent to PLT job, upper zones were re-perforated through tubing and the well was put back to production. Initially, there was some increase in production, however, production declined again within 2-3 months.

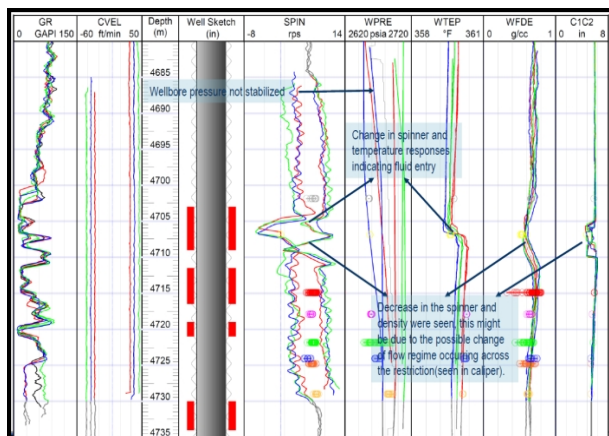


Figure 4: Well-B: Merged HPLT Log recorded with different speed shows variation of Pressure indicating unstable flow condition. Change of Spinner and Temperature responses indicate fluid entry.



Figure 5: Well-B: Scale came out along with CTU

Conclusions

1. DDW is a HPHT field with reservoir depth around 4500-5300 m. Trouble shooting of production problem through PLT Logging in this environment of high temperature (390-400°F) with hazardous gas production (H_2S & CO_2) was a real challenge faced by GSPC. There was also a limitation of tools in terms of exposure time to HT and limitation of cable in terms of gas entry and low breaking strength.

2. These problems were mitigated through meticulous planning, arranging proper tools & equipments and experienced manpower.
3. Though PLT job in Well-A was incomplete, yet it detected tubing leakage points and gave sufficient clue about production profile. Maximum contribution was from Zone-1, minor contributions were from Zone-3, 4 & 7 while rest 6 zones were not contributing. Subsequently, the well was worked over and was put back to production. Difficulties faced in this job were a learning experience which helped in further micro level planning for Well-B.
4. PLT detected scale deposition in Well-B against the perforated intervals. Obstruction in casing was observed below Zone-4.
5. It was also concluded that fall in production in Well-B is due to deposition of scale / choking of perforation and possible reservoir damage.
6. In well-B, about 83% of gas contribution from zones below Zone-3. Subsequent to PLT job, upper 4 zones were re-perforated which resulted in some enhancement of production.
7. HPLT in Well-B also helped GSPC in investigating the causes for deposition of scales.
8. The detection of scales has also led to confirm that there is water production but source of water could not be identified as PLT tool got held up below 3rd zone. Suspected water bearing zones were carefully avoided during perforation, however, channeling cannot be ruled out.

Forward plan

Work over and clearing the scale in Well-B seemed to be a very time consuming and expensive task in this hostile environment. To bring the Well-B back to production, it has been planned to make a slimhole side track with barefoot completion to continue gas production from these reservoirs taking care of not penetrating lower water layers. One water zone at the upper level may be isolated with inflatable packer.

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