CASE STUDY – MANAGED PRESSURE DRILLING

Tripping Operations at a HP Ballooning Well

Challenge

Specific Deep Basin formation groups in Western Canada can exhibit significant potential of drilling into High-Pressure (HP) zones. In a well that has been drilled in Northern British Columbia, Canada, a HP zone in the Doig Formation was encountered while drilling ahead vertically in the production section.

While drilling ahead vertically at ~2000m, 500m passed the intermediate casing point (ICP), sudden differential spike and motor stall incidents were registered twice, followed by 4m³ gain in 5mins. The crew decided to shut-in the well on MPD immediately and pressure built to 10,735kPa in 7mins. The gas kick was circulated out through MPD for over 30mins and the gas meter constantly registered 50kscm/day gas. The calculated pore pressure was determined to be 2200kg/m³.

Since HP was anticipated, the field crew was able to increase the drill mud weight in a timely manner and continued to drill ahead while attempted to bleed down the pore pressure by allowing a small amount of gas entering the wellbore to flare off. At 2079m, PWD ECD tool started to give incorrect data and the was a suspension of a washed BHA. Decision was made to trip out of hole.

Due to the suspected washed BHA, the operator decided to perform a displacement to kill mud on bottom to kill the entire wellbore. After the displacement to 2150kg/m³ density fluid, the well failed the flow check. The well was shut-in on MPD and a build-up test was performed with a suggested 2280kg/m³ equivalent mud weight. After circulated gas and further weighted up the kill mud to 2200kg/m³, the well failed flow check again.

At the time, a custom tripping plan was required as there were few challenges:

- Failed flow check meaning a higher out of hole ESD would need to be established, a heavier weight kill mud is required;
- Needed to investigate of the reasons of the well was experiencing losses (i.e. fracture gradient, well ballooning, etc.);
- Needed to confirm equipment's ability for holding backpressures due to suspected washed tool.

Solution

To avoid further stress the wellbore, the decision was made to displacing entire well back to drill mud while circulating gas and relax formation through reduced surface applied backpressure. A balloon test was proposed and conducted, and well ballooning was confirmed. To properly relax the ballooning, the best practice that Beyond engineering team recommended was to reduce ECD and allow flow backs, instead of increase ECD and allow the fluid to further invade the formation to worsen the fluid loss. While continued circulating drill mud, a 100litre loss to the formation was observed, when further stepped down backpressures the 100litre loss was gained back with 1-2kscm/day gas. The equipment had the ability to hold some backpressures, which made strip out of hole an available option when planning for come out of hole.

In order to reduce the high ECD generation phenomena when displacing the entire well to kill mud on bottom and to prevent further stressing the ballooning effect, the proposal was made to the operator that while stripping out of the hole, to fill the metal displacement volume from the top of the well with heavy kill mud and establish the overbalanced out of hole ESD. This method would require the well to take the proper volume as circulation wasn't an option due to the building of kill mud at the top of the annulus.

Prior to the second attempt of come out of hole, the build-up test suggested the pore pressure was bled down to 1824kg/m³. By precisely tracking the well volume and adjusting the backpressures and trip speeds while strip out of the hole, the well was able to pass the flow check at 1000m. The RCD bearing was safe to be removed and the well was opened to the atmosphere and pulled to surface for new tools.

Table 1 below shows the summary from the day of kick encountering to resume drilling ahead after a tool trip.

Date	Mud Weight (kg/m³)	Max Influx Volume	Max Loss Volume (m³)	Shut-in Pressure (kPa)	Max Gas Rate (kscm/day)	Pore Pressure (kg/m³)	Hole Depth (m)
07-Feb Drill Ahead	1600 - 1615	8	-7	10,735	50	2200	2037
08-Feb Drill Ahead	1650 - 1770	6	-5	-	1.05	2200 - 2305	2079
09-Feb Circulate	1740 Displace to 2200	1	-1	1st: 2690 2nd: 2777 3rd: 2825	3	2305	2104
10-Feb Circulate	2200	2	-1	1st: 2527 2nd: 2338 3rd: 1216	27	2305	2104
11-Feb Circulate	2200 Displace to 1770	2	-3	EOD: 2862	23	1840	2104
12-Feb Circulate	1770 - 1700	2	-5	EOD: 1216	21	1840 - 1850	2104
13-Feb POOH	1700 Backfill with 2200	1	-6	EOD: 610	27	1840 - 1850	2104
14-Feb RIH	1700	10	-5	EOD: 3736	21	1840 - 1850	2104
15-Feb Drill Ahead	1700	1	-1	-	25	1840	2156

Table 1. Operation Summary

RESULTS

There were multiple good practices that allowed the reduction of NPT when drilling through the challenging Doig formation:

- Early kick detection enabled in-time influx control through MPD equipment. MPD equipment was utilized to circulate out the gas in a very controlled manner and helped bleed off the ballooning pressures.
- Balloon test helped accurately identify the reason for losing the fluid, and avoided to be mistaken and treated a gas kick.
- Offsets and experiences on handling the challenging situations allowed Beyond to come up with innovative tripping plans in a timely manner. The tripping plans were tailored for targeting different EMW targets at different formations to ensure the well was overbalanced when RCD bearing was removed.