Gas broach leads to unique relief well intervention to protect production platform

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WHEN AN UNPLANNED event beneath a platform offshore escalated to a seabed gas broach, an Incident Management Team (IMT) successfully plugged and abandoned the blowout well after the open-hole annulus collapsed around the drillpipe. Subsequent damage assessment revealed one of the production wells on the platform was severed below the mudline and above the subsurface safety valve (SSSV). Without the relief well, high flow potential gas below the SSSV posed unacceptable danger to the platform, with no practical way to intervene if it failed. Surface intervention options posed unacceptable risk. With the relief well, the problem was safely and successfully isolated. The relief well was then turned into a producer.

INTRODUCTION

The operator planned to deepen and recomplete one of its existing gas wells to increase capacity. The wells team abandoned the lower portion of the depleted well and sidetracked from the 13 ⅜-in. casing to target a productive deeper sand. The well was located on a 12 slot steel jacket platform in 11 m of water. The well was drilled with a self-erecting platform rig and tender barge. On Christmas Eve, 2001, just prior to setting the intermediate 9 ⅝-in. casing, a gas kick was taken from a sand stringer thought to be depleted. During the attempt to circulate out this kick, the well broached to the seabed below the platform.

The rig was abandoned and the barge was pulled off location without incident, injuries or pollution. The well flowed gas to the seabed for approximately 10 hours and then bridged, with no apparent major damage to the rig or platform with the exception that one wellhead and conductor had subsided approximately 14 in.

Diagnostic wireline logs run in the drillpipe of the well indicated gas was cross flowing in the lower portion of the annulus between normally pressured sand stringers and shallower depleted sands. Multiple annular bridges had formed between the cross-flowing zones and the sidetracked casing window. The IMT subsequently plugged and abandoned this well by perforating the drillpipe and squeezing cement in sequential zones above the cross flow.

A replacement well was drilled from the platform parallel to, and approximately 50 m lateral proximity from, the cross flowing reservoir and produced it at high rates to deplete the pressure. The new well included an electromagnetic ranging bypass survey to fix the relative down hole positions between the two wells. This allowed the parallel producer to be quickly turned into an intersection and hydraulic kill relief well if needed.

While bringing the platform wells back on production, unusual gas bubbling surfaced at sea level when attempting to pressure up the tubing of the subsided well. Diagnostics performed on the well concluded that its tubing and all protective casing strings were open to the seabed just below the mudline. The tubulars were assumed flow cut at the 26-in. casing shoe by high velocity sand erosion as gas expanded at the seabed around the conductors during the broach.

The tubing pressure and completed reservoir was being contained by the SSSV and possibly buckled tubing, both in unknown condition. This situation left the subsided well with a questionable single well-control barrier and no practical way to intervene, short of a relief well, if that barrier were to fail. Uncontrolled flow at the seabed under the platform would jeopardize the entire asset, which included a second 12 well platform and production facility connected by bridges. This facility was a prolific gas producer.

INTERVENTION STRATEGY

The IMT assessed several options to isolate this problem well. The plan chosen by the operator optimized the primary design criteria of:

- Minimizing risk to the IMT, the environment and platform assets;
- Continuing production from adjacent wells during intervention;
- Provide adequate evidence that the well was isolated when the project was completed.

The basic design strategy was to drill an intervention well, from the adjacent bridge connected platform and intersect the problem well at its production casing string both above and below its perforated interval in the producing reservoir. After intersection was confirmed using electromagnetic homing-in technology, a liner would be set in the new well. The lower intersection zone would then be perforated through both strings using oriented perforating guns.

With adequate hydraulic communication confirmed, the upper intersection zone would be perforated using the same technique. A re-settable test packer would be used to confirm circulation between the lower and upper perforations through the problem well's production casing. With this confirmed, a retainer would be set in the intervention well just above the lower intersection and cement circulated down the drillstring, through the retainer, up the problem well's production casing and back into the annulus of the intervention well via the upper perforations. The intervention well would then un-sting from the retainer and circulate out excess cement from its annulus to confirm cement placement through the problem well.

This would cement the problem well's tubing, perforations and production casing annulus with cement between the lower and upper intersection depths. As a final assurance, a balanced cement plug would be set across the upper perforations and squeezed into the problem well pushing it up its tubing to a height above the production packer. With the intervention completed, the intervention well would be turned into a producer, replacing the isolated problem well.

DRILLING INTERVENTION WELL

The IMT managed the project. This team consists of engineers and managers from the operator and from long term contracted service companies, including: **Smedvig**, **Schlumberger**, **Baker**, **Red Baron**, and others. The specialist design and supervision team was managed by the **John Wright Company** and included: **Well Flow Dynamics**, **Vector Magnetics** and **Scientific Drilling International**.

The intervention well was spud in September 2002 from an existing low-producing well from the adjacent bridge connected platform. This well was plugged and tubulars cut and pulled to allow sidetracking from its 13 ⅜-in. casing using a whipstock.

The intervention well was directionally drilled toward the target using conventional steerable motors and measurement while drilling (MWD) tools. When the surveyed proximity between the two wells was 30 m, electromagnetic homing-in tools were used to guide the relief well toward the target well casing.

The 9 ⅝-in. casing on the intervention well was set parallel to and approximately 3 m proximity above the target problem well's 9 ⅝-in. casing. The intervention well intersected and then skidded along the target casing from 2,936 m md to 2,986 m MD.

Due to the complexity of the attempt, maintaining the desired proximity between the two wells required multiple homing-in runs. High-speed north seeking gyro surveys were made in tandem with the homing-in runs. The upper intersection perforating target was chosen just below the 9 ⅝-in. casing shoe.

The intervention well was purposely steered away from the target casing below this depth to maintain approximately 4 m proximity when crossing the problem well's perforations, to avoid premature communication. The intervention well was then steered back to the lower intersection where the wells touch again between 3,356 m and 3,388 m in impermeable shale below the reservoir.

The intervention well's 7-in. liner was set and cemented at this depth. With this accomplished, the lower intersection zone was perforated through both strings using TCP guns with 0-5-0-355 deg phasing oriented with a north seeking gyro toward the target casing.

Hydraulic communications tests through the perforations were excellent with negligible pressure drop. Once adequate hydraulic communication was confirmed, the upper intersection zone was perforated using the same technique. A re-settable test packer was run to confirm circulation between the lower and upper perforations through the production casing of the problem well.

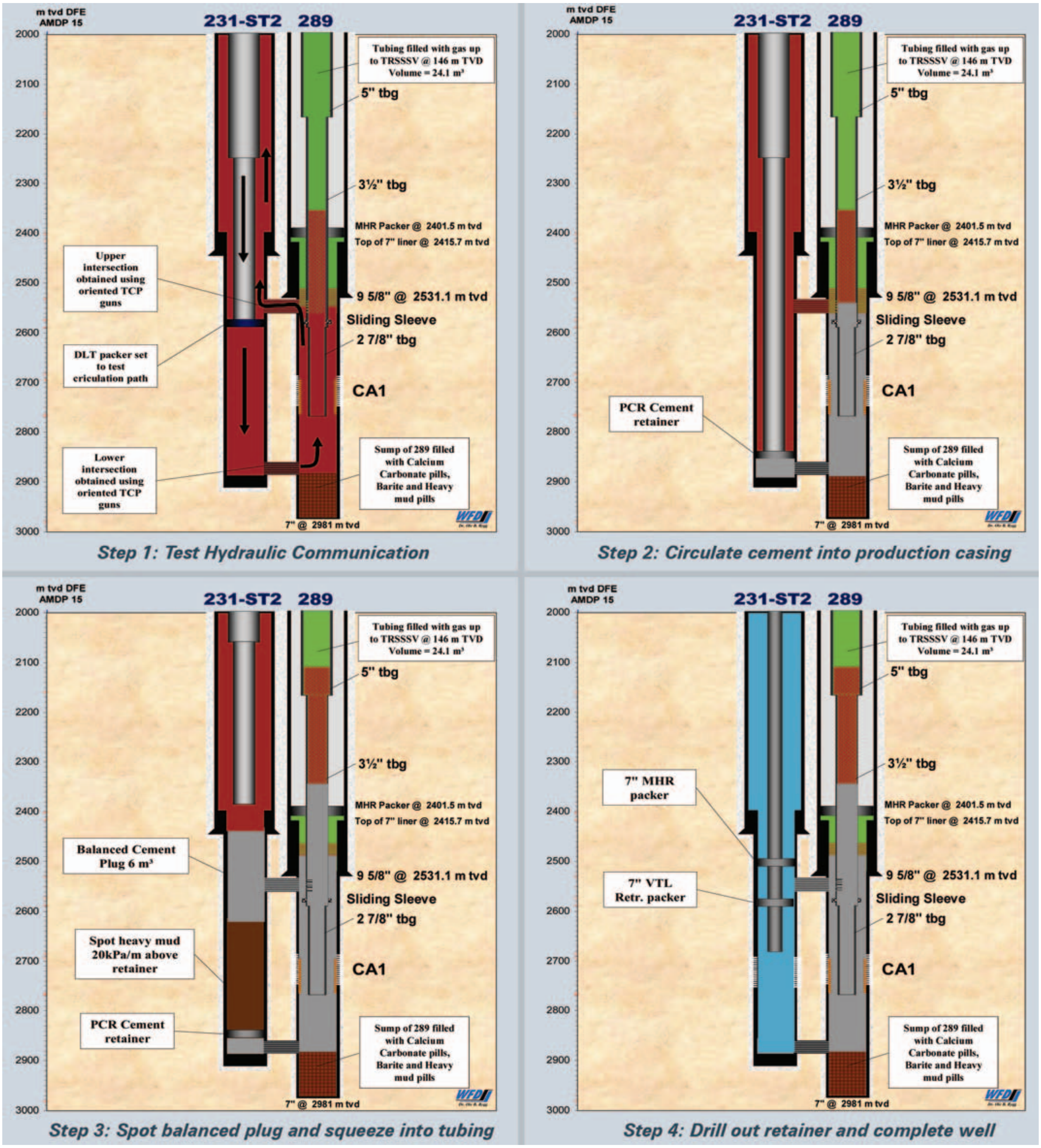
When circulation was confirmed, a cement retainer was set in the intervention well just above the lower intersection. Cement was circulated down the intervention well's drillstring, through the retainer, up the problem well's production casing and back into the intervention well's annulus. This plugged the problem well's tubing, perforations, and production casing annulus with cement between the lower and upper intersection depths. All diagnostic data indicated the problem well was isolated as designed and the project objectives met.

As a final assurance, a balanced cement plug was set across the upper perforations and squeezed into the problem well designed to push the top of cement into its tubing above the production packer. With the intervention completed, the intervention well was converted into a producer, replacing the problem well.

SUMMARY AND CONCLUSIONS

This technically challenging intervention was an industry first. The design objectives were achieved and the well was completed within the time and budget estimated during the design phase of the project.

The upper intersection was achieved without problems and provided more than 40 m of less than 0.1 m proximity (edge to



Step 1: Test Hydraulic Communication

Step 2: Circulate cement into production casing

Step 3: Spot balanced plug and squeeze into tubing

Step 4: Drill out retainer and complete well

edge) between the two wells. No problems were experienced when drilling alongside the 9 ⅝-in. and 7-in. liner casing strings, even with several collar connections and a high density of centralizers.

While drilling at 3,388 m alongside the problem well for the lower intersection, losses occurred into the problem well by a suspected hole rubbed into the 7-in. liner. This caused an increase in project duration, but was resolved by running an external casing packer to isolate the hole from the intervention well's 7-in. liner string cementation.

The upper and lower intersections were perforated with an oriented TCP gun with good results After testing the communication between the two intersections, the plugging operation went as per textbook. The final squeeze plug was held for 12 hours and the final pressure test indicated the operation was a success.

A self-erecting tender assist rig was selected to implement the plan. It provided rapid escape capabilities in the event of an emergency through barge disconnect, large deck space and variable loading, large liquid mud storage and mixing capabilities, three mud pumps, large cranes, machine shop, adequate power and good accommodation with office facilities.

The total project took 76 days.