Boots & Coots Team Controls a Geothermal Well Blowout

CUSTOMIZED DEBRIS CONTROL SOLUTION ENABLES OPERATOR TO CONTINUE DRILLING WELL

MOKAI GEOTHERMAL FIELD, NEW ZEALAND

CHALLENGES

- Debris management
- Continued circulation despite presence of H_2S

SOLUTIONS

- Well control preparedness
- Debris catcher fabricated on site
- Underbalanced polymer mud system

RESULTS

Using an innovative method of debris control, the Boots & Coots team successfully regained control of the well, and the customer was able to continue with the drilling operation.

OVERVIEW

An operator in New Zealand was drilling a geothermal well when, during preparations to run 7-inch casing, the drillstring was pulled from the hole and a gas kick was swabbed in. The well was shut in on the blind rams and the casing pressure rose to a stabilized value of 128 psi. Mud weight was increased to 9.3 ppg, and, by lubricating mud into the well and bleeding off gas and light mud, pressure was reduced to 24 psi, with a mud weight coming back between 8.5 ppg and 8.9 ppg.

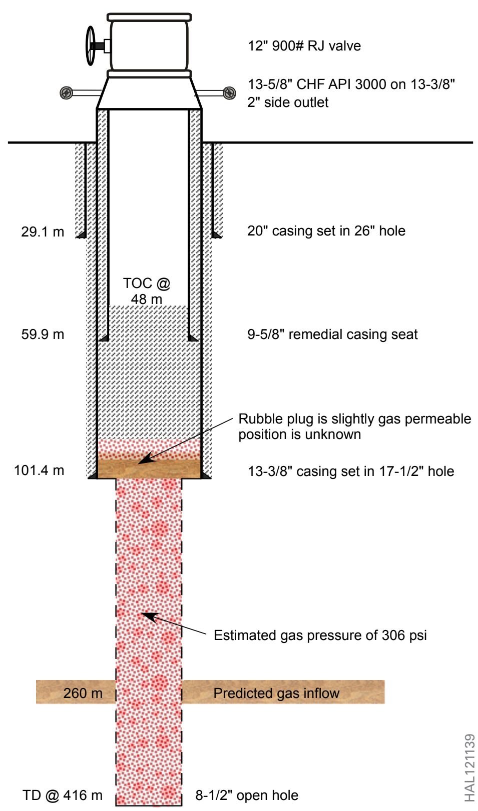
Coiled tubing was rigged up and run in the hole while pumping water. After taking weight at 96.3 meters (316 feet), the coiled tubing was washed to a maximum depth of 97 meters (318 feet). The obstruction was interpreted as debris that had been blown up the hole and had bridged the well during the kick.

The well was shut in again and control was regained. A balanced cement plugging job was then conducted inside the 13-3/8-inch casing. A total of 10.1 bbl of 18.2 ppg Class G cement was spotted with the bit at 92 meters (302 feet).

After waiting on cement, the well was static, but the pipe was stuck. Circulation was possible, but eventually, the drillpipe was cut and a 7-inch washover assembly was used to wash over the drillstring down to 41.4 meters (136 feet), which was the top of the drill collars.

A 9-5/8-inch washover assembly was then used to 52 meters (171 feet), at which point metal shavings were detected in returns. A leak-off test indicated a possible hole in the 13-3/8-inch casing, and an 8-5/8-inch washover assembly with a 9.2-inch shoe was used to free the pipe.

To control the leak at +/- 50 meters (164 feet), a string of 9-5/8-inch casing was set at 63.5 meter (208 feet) rotary kelly bushing (RKB) [59.9 meters (197 feet) ground level] and cemented to surface.



The Boots & Coots team's goal was to protect the 13-3/8-inch casing shoe after reestablishing communication with the hole. The team's tasks included:

- Drilling underbalanced
- Maintaining circulation despite presence of H_2S
- Ensuring continued circulation without plugging chokes

With the 9-5/8-inch casing and the cement plug in place, planning began for reentry operations. Briefly, the plan was to drill out the cement plug and debris bridge to reestablish communication with the hole. It was fully expected that, when communication was established, a gas kick would be taken, but, by maintaining sufficient hydrostatic head, gas could be released at the surface in a controlled manner.

The primary well control issue during this operation was the possibility that the pressure below the cement plug would fracture the 13-3/8-inch casing shoe and eventually breach to surface if the gas were allowed to migrate up the hole without being allowed to expand.

Although no reliable estimate of shoe strength was available, it was thought that the shoe would break down between 300 psi and 380 psi (approximately 19.1-ppg and 24.2-ppg mud weight equivalent). Further, it was estimated that the gas bubble at the bottom of the debris bridge contained approximately 306 psi.

To prevent overpressuring the shoe when hydraulic communication was established, it was decided to drill out the cement (and debris bridge) underbalanced. This would be accomplished by drilling with back pressure on a choke with a mud weight of approximately 12.5 ppg. A choke pressure versus drilling depth schedule was developed to achieve an underbalance of 40 psi.

Plans also had to include measures to ensure that once communication with the gas bubble was established, circulation would continue. The Mokai wells are known to produce H_2S, and preparations were made to enable personnel on the rig to continue circulating the gas bubble from the well even if H_2S was detected. A "cascade" system was installed to provide breathing air to persons located at key positions on the rig.

Mud weights were chosen to limit mud losses after the gas was circulated out. The weak downhole formations (mainly tuffs) were drilled with mud weights no greater than 9.4 ppg. Plans were made to be ready to fill the hole with water if prolonged mud losses occurred. Once the well became stabilized, the situation would be reevaluated and, if practical, the team would drill/wash to bottom and set the 7-inch casing as planned.

Since underbalanced drilling would be performed, it was necessary for plans to include a means by which to prevent sudden surges of solids from plugging the chokes. A rock-catching device was designed and fabricated for this purpose. Two rock catchers were built, each with an internal removable basket (screen) in which solids were collected. Three screens were fabricated, allowing personnel to redirect flow to the other choke manifold, isolate a plugged rock catcher, and quickly change the screen.

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Rock catchers on the choke line

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Choke Manifolds: Manual (left) and Hydraulic (right)

Boots & Coots successfully dealt with this highly unusual well control situation in an innovative fashion, enabling the customer to continue with the 7-inch casing program and subsequent drilling of the 6-inch hole section.

This configuration required two choke manifolds: a 3-1/16-inch, 5,000-psi manifold equipped with 2-inch manual chokes and a 3-1/16-inch, 10,000-psi manifold equipped with 2-inch hydraulic chokes hired from Boots & Coots. A "watermelon" was fabricated from casing and tied to both manifolds and to a line to the rig's mud-gas separator, and a gas vent line was run from the mud-gas separator to a safe offsite exhaust location.

Rock catchers collect large amounts of cuttings

A polymer mud system that would retain rheological properties at the anticipated temperatures was chosen. The fact that the weight and gel strength of the system employed could more easily be changed than a conventional system was one reason it was recommended. The 12.5-ppg mud was designed for a yield point of 20 to 25 (lb/100 ft^2).

Since the exact depth at which overpressure would be encountered was unknown, it was important to maintain sufficient string weight to remain significantly pipe heavy. The criterion employed was to maintain a string weight of at least 1.5 times the snub force.

Controlled drilling of the cement began at a maximum rate of penetration (ROP) of 6 meters (20 feet) per hour while taking returns through the choke line. In part, the low ROP was intended to test the function of the rock catchers and to give personnel an opportunity to practice changing the screens and controlling the choke pressure before encountering gas.

At a depth of 68 meters (223 feet), a kick drill was performed; circulation rate was increased to 100 SPM and large amounts of cuttings were being caught by the rock catchers, so the yield point was reduced to 20 and the pump rate was dropped to 60 SPM. On reaching a depth of 105 meters (344 feet) RKB, the bit was picked up off bottom and 12.5-ppg mud was circulated.

After 40 minutes of circulating through the choke, a gas kick was taken. Gas and debris came rapidly to surface and the rock catcher plugged up; however, the design of the rock catcher allowed steam and gas to channel through the debris and to escape out the vent line to the remote discharge point. The bubble of gas and steam soon dissipated.

A gain of 31 bbl was measured in the pits, and temperature at the blowout preventer (BOP) rose to 74°C (165°F). Casing pressure rose to 240 psi, but began to decrease as 10 bbl of 12.5-ppg mud was pumped down the drillstring, followed by bullheading 27bbl of mud into the annulus to reduce pressure and cool the stack until the wellhead pressure was zero and the annulus was on vacuum. During subsequent circulation, losses dropped from 3 bpm to 1.1 bpm. A total of 187 bbl of 12.5-ppg mud was lost.

The well was circulated to 10 ppg while continuing to take 1 bpm in losses, then the mud system was cut back to 9.5-ppg mud while circulating. Dynamic losses were considered acceptable, and no gas or bridges were encountered.

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