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Aerojet Nuclear Company

Interoffice Correspondence

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To: File

CASING EVENT, RRGE NO. 1 WELL - Kun-138-75

On February 23, while forcing cement into the bottom stage of the production casing (from plug at 3642 ft up to approximately the 1600 ft level), the cement stopped moving freely. Halliburton pressured up to 2100 psi (at surface), about 80% of design burst pressure rating for the coupling-joints, but 200 psi overthe rated test pressure of 1900 psi (for the 54.5 lb/ft string of pipe). The cement stopped moving entirely (no pressure drop when pumps stopped). Approximately 30 seconds later, the pressure released as the exposed casing jumped out of the hole "several feet" once, then again a second or two later. The chief driller and one of his crew both witnessed the casing jump. Both said the casing jumped high enough once or possibly two times to hit the hook, 4-1/2 to 5 ft above (estimated travel distance to the hook). In fact, the hook was sprung open, requiring more than a light touch. R. C. Stoker, ANC, witnessed three pulses of water out the exit line, where he was measuring displaced water.

The casing was lifted after the event, and the weight corresponded to approximately 6 sections (joints) 230 ft., from the surface. That joint also showed difficulty in being made up by the casing crew (shown on strip chart recorder). Several hours later, this casing was carefully lowered and turned 9 turns--it held 100,000 lb lift and 500 lb pressure (i.e., the joint was miraculously screwed together). No further trouble was encountered; the cement job was later finished from the top. A good cement bond log (sonic) was obtained, assuring that the two stages of cement had met.

However, the cement still filled the pipe beginning at the 2835 ft level. While drilling this out on February 26, the drill encountered metal at 3325 ft. At this time, it is still not certain if the casing was collapsed, crumbled, or merely parted there. The 3325 ft level is 7 ft below a coupling. Since then, some 7 or 8 milling bits were used to traverse through to the 8335 ft level. Beyond that point, no metallic resistance was encountered (except for metal chips) all the way down to the first differential float collar at 3600 ft.

Other relevant facts are that the hook and elevators (the elevators supported the casing) are supported by eight (8) 1-3/8 in. diameter steel cables. When the casing was screwed back together, the top was 7 in. lower than it had been originally. The casing was lifted approximately (eyeballed by the driller) 1 ft off of the cement plug before the cementing operation began. This was a "tag" lift; i.e., the elongation of the pipe was already included. This positioning of the casing was performed prior to filling the casing with cement. The cement density was 15.4 lb/gallon.

The casing consisted of a top joint 30.6 ft long of 61 lb/ft, 41 joints of 54.5 lb/ft to a depth of 1665 ft followed by 50 joints 61 lb/ft to the bottom at 3642 ft less the 1 ft lift. Before displacement began, the casing was full of cement. The cement had a hardening retarder mixed with it to prevent rapid setup in the high temperature environment. Cement displacement forced cement out through the bottom of the casing (casing shoe) and up the outside annulus around the casing to the 1824 ft level. The latter was determined from the sonic cement bond log.

The postulated event leading to lack of flow of the cement through the casing shoe is as follows:

> Filling of the drill pipe with cold cement inside a hot water well created a hydrostatic head difference capable of stretching the casing approximately 10 in. However, the cold cement probably cooled off the casing somewhat, causing it to contract a few inches (6 in. per 25°F). However, as the cement warmed up, this contraction disappeared leaving only a few inches (or less) between the shoe and the plug. As the cement began to harden, pressure drop through this space increased, necessitating that Halliburton increase pump pressure in the hope of maintaining a reasonable displacement flow. Unfortunately, pressure inside the casing also caused it to stretch, approximately 1 in. for each 100 psi. Eventually the gap between the casing shoe and block became closed, virtually blocking further movement of the cement.

Rupture of the joints was probably caused in-part by the fact that the cement and the casing threads were relatively cool while the coupling threads were warm, thus weakening the burst pressure of the joints.

The event described above was a result of application of normal oil-well technology. Though the results were unfortunate, the event is not considered to be an incident in the formal sense. Note, the cement blockage was not the cause of the casing rupture, nor did the blockage prevent obtaining a satisfactory cementing job. The cause of the casing rupture was simply the high pressure deliberately applied in an attempt to move the cement. This pressure was well below the rated casing strength and even the joint strength. The loss of the 10 ft section of casing is not considered significant to the completion of the hole or the safety of the aquifer. For instance, the decision might just as well have been made to set casing only to 3300 ft based on difficulty to interpret geologic data. Furthermore, the entire string is still holding up to a test pressure of 300 psi without leakage (i.e., the cement at the 3325-3335 ft level is holding this pressure).

Appropriate action needs to be taken to minimize the chance of such events occurring in the future. In this case, project personnel assumed (obviously incorrectly) that a cementing job was a routine service job by Halliburton. We did participate in the decisions relating to the geology, the likely lost-circulation zone, etc. relative to staging of the cement. We did not, however, review the hardware details. It appears that many of the characteristics of geothermal well drilling differ noticeably in nature, the appropriate technique, and the possibility of developing problems compared to standard oil well drilling

practices. Geothermal Project personnel will continue to carefully examine and monitor the drilling activities on the geothermal well, even activities in which they have zero prior experience. Approval of all practices shall be required by Project personnel (not necessarily in writing). Note, the relationship between project personnel and REECo drilling supervisors has not required formal written approvals (which would be a cumbersome inconvenience for field drilling operations). Project personnel have never had to go on record disapproving any of the operations, and the REECo-NVOO personnel have been extremely cooperative and understanding.

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