Welltec Completion Solutions Metal Expandable Packer and 2nd Stage Cementing For Geothermal Well Re-lining

Kyle Ivar Jamieson[1], Espen Dalland[1] & Genevieve Cherube Carlos[2]

[1]Welltec A/S Unit 21-1, Level 21 Menara Prestige, 1 Jalan Pinang, MY-50450 Malaysia

[2]EDC (Energy Development Corporation) 40th Floor One Corporate Centre, Julia Vargas Corner Meralco Avenue, Ortigas Centre, Pasig City 1605, Philippines

kjamieson@welltec.com edalland@welltec.com carlos.gr@energy.com.ph

ABSTRACT

EDC (Energy Development Corporation) in the Philippines faced integrity issues in 3 wells due to casing corrosion and collapse with the 9-5/8" and 13-3/8" casing on a geothermal well and was required to re-line with 7" and 9-5/8" casing with a metal expandable packer WAB (Welltec Annular Barrier) to reinstate integrity of the 9-5/8" and 13-3/8" casing. This paper will discuss an operation in which the new 7" and 9-5/8" casing was deployed and set inside 9-5/8" and 13-3/8" casing using an 812WAB and 1214WAB in conjunction with 2nd Stage Cementing Collar.

Results, Observations, Conclusions

The WAB and 2nd Stage Cementing Port Collar was deployed to setting depth and cementing tool consisting of two cups style packers and an injection port positioned in-between was used for both setting/expanding the WAB. Then, opening the cement collar and performing the cementing operation and subsequently closing the cement collar, all in the same run. The fluid level was below the setting depth, so the equipment was installed in a "dry" well and throughout the operation continuous cooling was performed by pumping water down into the well.

By establishing returns to surface after opening the stage collar we were able to get a positive confirmation of the WAB being set, the cementing operation of the annulus was completed in the fully controllable annular volume ensuring 100% cement coverage. As a redundancy in case trapped water should occur, multiple burst discs have been integrated in the WAB to avoid potential casing collapse or deformation.

As a result, the client could put the well back on production with full integrity, albeit with a slightly reduced wellbore diameter.

Novel/Additive Information

Welltec's WAB metal expandable packer minimizes completion and workover risks through quick and simple isolation of the integrity issues, capable of offering high temperature metal to metal sealing whilst ensuring a life of well product.

1. INTRODUCTION

1.1 Background

Geothermal producing wells frequently face casing integrity issues such as collapse and burst. These integrity issues are attributted to the extreme temperatures and temperature reversals (DeltaT) where the wells are produced and then quenched repeatedly. This problem results to reduction, or even loss of, production.

In addition, tapping production from a low pH (acidic) reservoir brings concerns of corrosion. This leads to thinning and pitting of casings, thereby compromising the latter's integrity.

Literature shows that the utilisation of low pH two-phase geothermal fluids has been investigated (Lichti et al, 2002). Corrosion is, indeed, a concern in geothermal environments (Richardson et al, 2014). In fact, studies in utilisation of chrome alloys instead of carbon steel casings, in acidic wells has been pursued (Yanagisawawa et al, 2020).

Given the above, low pH wells installed with carbon steel casings are cases in question and potential candidates for well intervention.

Drilling new wells is more expensive than working over existing wells with integrity issues; provided a viable solution is implemented and can be critical to the viability of the project. This also enables the customer to keep the original wellbore and is the preferred option to new wells..

Traditionally, geothermal wells that faced integrity issues would require a comprehensive fishing and remedial work over program to cut and pull damaged casing strings and deployment of new casing and cement long sections in place can be problematic and overstreaching the length of the cement columns may result in losses and/or further remedial operations.. To casing bulges where the bulge has caused the loss of production, mechanical clearing is necessary to provide access of the geothermal fluids from the wellbore. In addition, the relining with casings and cementing of the relined casings is necessary to preserve the integrity of the well and keep it safe for production and enable efficient production and prevent produced water going into the casing leak.

1.2 Statement of the Problem

Given the method of repair of wells with casing bulges, one major concern of the client (EDC) is if the intervention will be done on a low pH well. This is because the relining method where a bridge plug is set and then drilled and chased to bottom is not an option following a prior experience on another low pH well whose liners were discovered to have dropped to the open hole section (~200m below original depth) after only a year of utilisation. This well was eventually abandoned after a year when its second workover was unsuccessful in the pulling out of the sacrificial liners.

Proceedings 42nd New Zealand Geothermal Workshop
24-26 November 2020
Waitangi, New Zealand
ISSN 2703-4275

This phenomenon is not surprising since the well is immersed in a low pH environment. The condition of the carbon steel liners are fragile and easily deteriorates when drilling tubulars come in contact.

With the above considerations, EDC's requirement is well relining without the need for a bridge plug drill out nor needing to access the perforated liner section.

2. TECHNOLOGY

2.1 Description of Technology

The technology involves the use of an expandable high temperature and steel reinforced packer and cementing port collar installed on the reline casing. The reline will then be cemented and no drilling of plugs be done.

Incorporation of the WAB (Welltec Annular Barrier) as part of a 7" or 9-5/8" casing relining operation where the 812WAB or 1214WAB is set and expanded by pressure inside the previous casing string in this case 9-5/8" and 13-3/8" casing. This relining operation prevents the need for a tie-back because the WAB is qualified to ISO14310 V0 when istalled in the previous casing string.

A second stage cementing port collar can be position above the WAB and can be open and cemented through after the WAB is expanded. This cementing port collar acurately places cement behind the casing above the WAB offering further integrity and isolation from the damaged 9-5/8" or 13-3/8" casing above.

2.2 Preparations and Developments During the Planning Phase

Since this is the first engagement of this client to conduct this kind of strategy and similar cases are limited, thorough design and procedure discussions were collaborated between EDC and Welltec. Some of these are summarized below:

- Due to the high production temperature (~320°C), therefore yielding a high delta temperature, trapped fluid within the reline will yield annular pressure build up type of collapse. It was therefore agreed that burst discs be installed between the top of the expanded packer and below the cementing collar. Redundant burst discs offset and 180° apart were installed. In addition, to prevent cement covering the burst discs, a metal petal basket was installed below the port collar.

- Further, with various pressure considerations, including the shearing requirement of the cementing tool after the cement job, WAB expansion pressure was reengineered and lowered to provide sufficient pressure difference with the cement tool shearing pressure.

- The WAB and cement collar were made up at the shop to ensure pup joints served as the handling sections during rig site implementation.

- All three applications were conducted in a Kelly-driven rig thus adjustments were made to the procedures to customize to the application. This allowed flexibility and widened the expanse of WAB application to Kelly-driven rigs.

- To accurately determine the location of the cement collar and the WAB, clearance between the two were measured then translated and marked respectively in the stab-in cementing string (drill pipe).

- In addition, during the execution, the cement collars were tested prior WAB expansion by attempting to close and open prior engaging the WAB to the parent casing.

2.3 Product Description

The WAB (Welltec Annular Barrier) is a full bore, expandable metal packer equipped with elastomer seals. The WAB is activated and set by applying pressure to the bore of the base pipe to which the expansion sleeve of the WAB is welded to. The running OD remains unchanged until activation and is not affected by wellbore fluids such as oil, gas and water. The entire setting process to expand the WAB takes less than 30 minutes and is controlled from surface. The WAB can be used for open hole zonal isolation, cement assurance or as a stand-alone barrier replacing the need for cement.

The WAB consist of a metal (Alloy-28) expansion sleeve mounted directly on to base pipe and welded in place. The weight, grade and ID of the WAB is the same as the casing or liner string being deployed. A valve block system is connected to the expansion port and acts as a pressure compensating device. It increases the differential pressure capacity across the WAB by ensuring the expansion sleeve is energized by the annulus (above or below) having the highest pressure. A significant advantage of the valve block system is that the expansion pressure is significantly lower than the differential pressure capacity of the WAB. The Valve block also includes a control valve that isolates the expansion port when it has reached the expansion pressure required to set the WAB. The control valve re-establishes the integrity of the casing after being sheared, leaving a non-compromised barrier envelop.

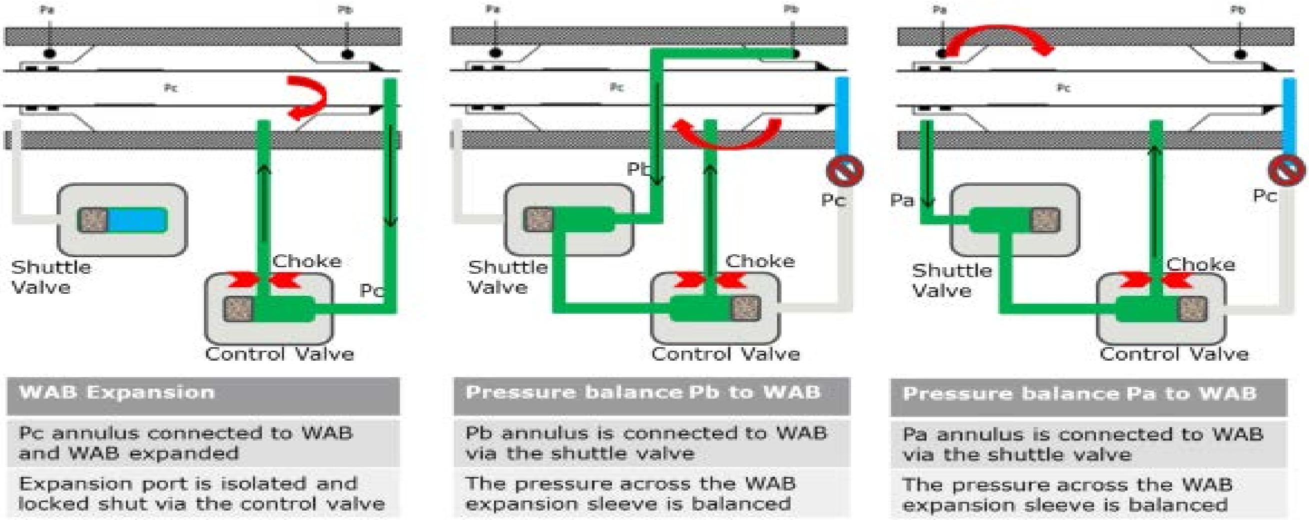

Figure 1: Valve Block System

As described above, pressure is applied to the well bore from surface, causing fluid to flow through a screen filter, a valve block and into the WAB, expanding it.

The inclusion of a valve block system can deliver several benefits:

1. Enables lower expansion pressure with high differential pressure capabilities.
2. Isolates the expansion port on reaching the final expansion pressure in order to retain casing burst and collapse integrity.
3. Enables pressure balance from within the expanded WAB to either the annulus above or below the WAB. This removes any collapse pressure on the expanded sleeve.
4. Makes it possible to self-isolate and shear the control valve in the unlikely event that integrity has somehow been compromised during deployment, thus maintaining a barrier envelope.

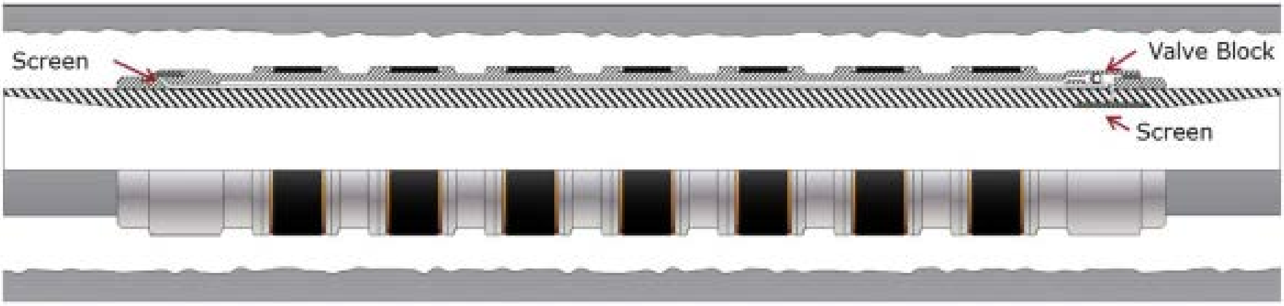

Figure 2: WAB Unexpanded

Figure 3: WAB Expanded

3. APPLICATION

The Leyte Geothermal Production Field, where these wells were located, placed EDC as the leader in wet steamfield technology. Given its more than 40 years in operation, production sustainability is one of the challenges.

The particular sector, where the wells are located, is called Mahanagdong. EDC has tapped this sector, among others, for power production since the late 1970s (Kingston, 1979). In its northeastern region, the fluids are acidic with high H_2SO_4 in liquid and H_2S in vapour (Salonga et al, 2004).

To illustrate this application, the client (EDC) had a requirement to incorporate a life of well, cement assurance solution to be used to replace the existing corroded casing string as part of a well-remediation programme. The solution is firstly required to provide a solid base for hydrostatic support to the column of cement slurry placed above the WAB and to prevent contamination of curing cement from crossflow of produced fluids / steam from below the casing. Secondly, the proposed solution will additionally offer anchoring support to the casing string in the event of thermal contraction / expansion of the casing string during production / shut-down operation.

The first application of the WAB was on a 9-5/8” relining of well with casing bulge (Figure 4). Milling activities and relining with cement were conducted. Clearing of the liners to total depth of the well was terminated earlier than programmed due to deteriorating condition of the liners. This was observed by comparing the downhole videos captured of the liners before and after drill pipe trips.

This application was successful, and the well was put back online.

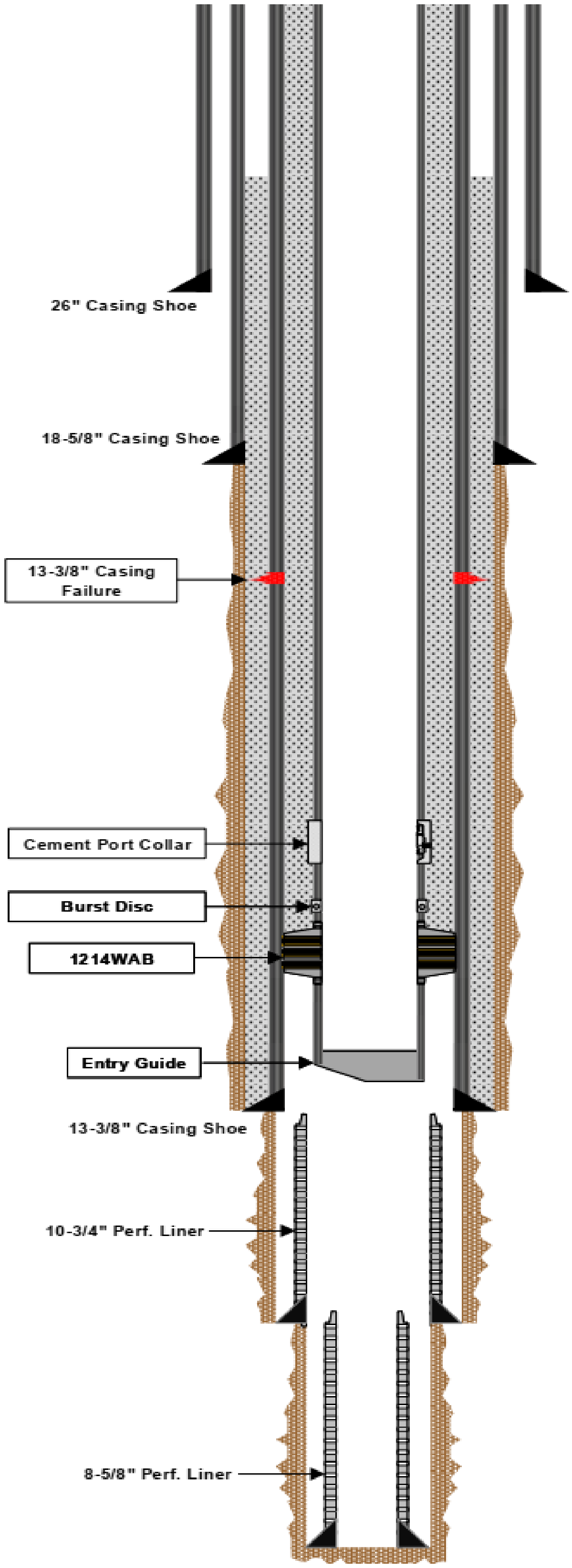

Figure 4: Well Schematic, "Well A", detailing the WAB Placement expanded inside the 13-3/8" Casing.

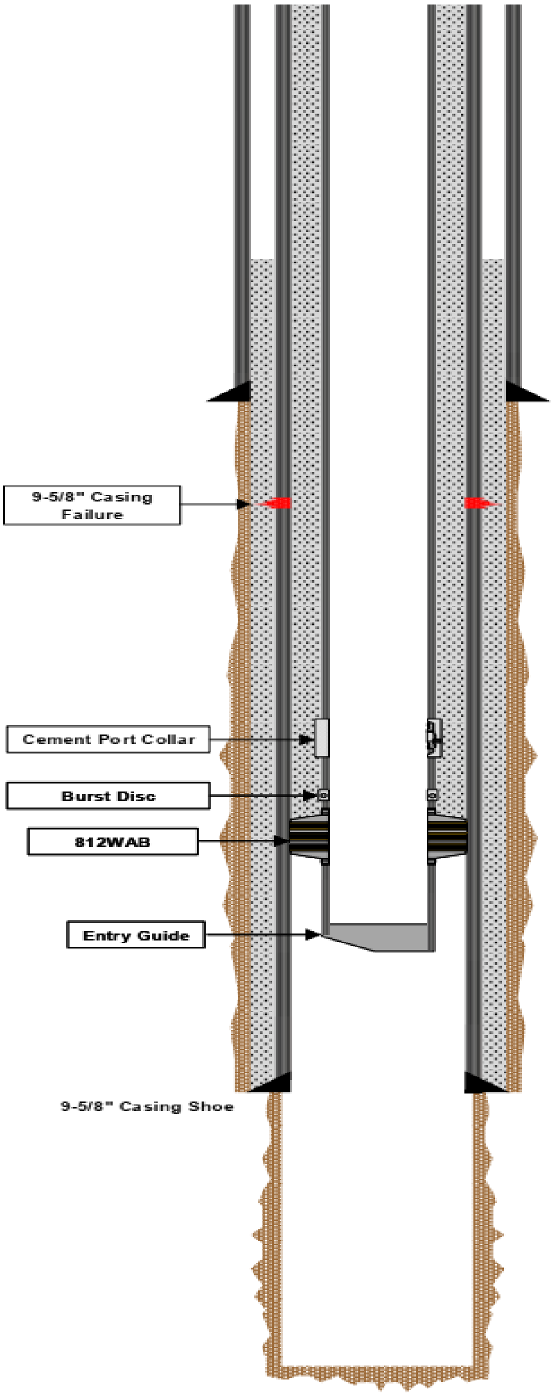

Figure 5: Well Schematic, "Well B", detailing the WAB Placement expanded inside the 9-5/8" Casing.

The second application was on a 7" reline that was necessary due to a thinning thus compromised 9-5/8" production casing (Figure 5). The workover was conducted to prolong the life of the well. In this case, chrome alloy casings were used for corrosion resistance. Following the prior experience of deteriorating well liners during rig workover, the clearing was terminated at a shallow depth. Again, the installation was successful.

On a side note, the initial plan for this installation was to use carbon steel casing for the reline. However, due to the success of the first engagement, the well owners pushed for the relining with chrome alloy casings.

The third application is on a well whose issue is a complete casing penetration after undergoing cyclic loads. The penetration allowed intrusion of a low temperature liquid thereby quenched its production. With the condition, squeeze cement jobs were deemed necessary prior the actual relining.

The WAB expansion itself was successful; however, the cementing activity was not. This was owed to insufficient overpull applied during the closing of the mechanically operated cement collar.

5. LESSONS LEARNED

During the course of the three-well campaign, aside from the preparations made during the planning stage, the following learnings were noted:

- One of the important lessons learned in the relining campaign was the impact of the valve block during production. Due to the high production temperatures, the fluid trapped within the valve will build up pressure and collapse the base pipe of the packer. This was observed in the first well where a restriction along the sleeve developed. Fortunately, this restriction did not prevent the well from producing and is still being used for production.
- With the above consideration, in the 7" relining activity, the valve block was removed since the hydrostatic pressure rating of the sleeve was already sufficient. Furthermore, for the third well, whose reline was of the same size as the first, an additional burst disc was installed in the assembly.
- It is important to accurately measure the weight requirements especially for the closing of the cement collar. Improvements in the cementing tool are also necessary to mitigate occurrence of any damage during the running in of the casing and to thus compromising its sealing integrity.
- Utilisation of this technology is feasible in chrome alloy casings.

5. RECOMMENDATIONS

From the three applications, below are the main recommendations:

1. It will be worthwhile to investigate improving the sleeve to address the concern on the hydrostatic head above the sleeve during long reline. This is in lieu of the valve block, which was necessary for the 1214 WAB (9-5/8" reline).
2. Available literature on the same type or method of application on geothermal wells is limited and we could probably note that the strategy is a novel one and further or similar applications are encouraged.
3. Furthermore, long relining jobs with possible requirement of multiple cement collars may be

worth investigating. This will allow design flexibility during the initial well construction.

With the project's overall success, this type of method of relining is now being adopted by EDC and is one of the primary options whenever a similar low pH well is being investigated.

Based on the foregoing, the utilisation of the WAB and the cementing collar is a promising technology and the preferred option in the repair and recovery low pH geothermal wells.

ACKNOWLEDGEMENTS

To all who were involved in the design and execution of the three relining jobs.

EDC Subsurface Well Services Vice-President, James E. Jumawan, for the permission to share insights on this paper.

REFERENCES

C.C. Jacinto, L. Nardi, M.F. Da Silva, M. Marques, P. Esteves, PMaciel and, R. Reves Vasques. *2015. World's First: Annular Barrier Installed in a Subsea, Deepwater Well without the Use of Cement, OTC-26122-MS, presented at the Offshore Technology Conference Brasil, Rio de Janeiro, Brazil, 27-29 October 2015.*

Kingston, R. (1979). The Tongonan Geothermal Field Leyte Philippines: Report on Exploration and Development. *Report. Kingston Reynolds Thom and Allardice Ltd., Auckland, New Zealand*.

Norsok D-10, Rev 4, June 2013 Well Integrity in Drilling and Well Operations.

Lichti, K. A., Klumpers, A., & Sanada, N. (2003). Utilisation of Acidic Geothermal Well Fluids Progress to 2002. In *25th NZ Geothermal Workshop* (pp. 197-202).

Richardson, I., Addison, S., & Lawson, R. (2014). Chemistry challenges in geothermal power generation. *API Powerchem. Australia*.

Salonga, N. D., Bayon, F. E. B., & Martinez, M. V. M. THE IMPLICATION OF 34S AND 18O ISOTOPE SYSTEMATICS ON THE SULFUR CYCLE IN MAHANAGDONG HYDROTHERMAL SYSTEM (PHILIPPINESS).

Yanagisawa, N., Sato, M., Osato, K., Yamamoto, Y., Sakura, K., Lichti, K., & Mountain, B. (2020). Corrosion Test of Casing Steel at High Temperature Acid Condition. *In 45th Workshop on Geothermal Reservoir Engineering.*