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Enhanced The Effectiveness Of Workover Program And Well Integrity By Combining Accoustic Ultrasound Leak Detection And Pressure Thermal Log In Depleted Mature Field South Sumatera - Indonesia

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Abstract. The evaluation of flow profile in the wellbore system is an important part of mature oil and gas field development. It is often complicated by life cycle of wells such as well design, completion strategy and production or injection phase. The high cost and tight economic margins require that the chosen well surveillance technique not only provides more effective workover program but also carries an acceptable risk in term of the project cost and safety. One of many well-known technologies is acoustic ultrasound leak detection and pressure thermal log. The objective of this paper is to show how a new approach of ultrasound leak detection surveillance technique combining pressure thermal log can be used to enhance the effectiveness of workover program in mature oil wells.

Accoustic ultrasound data acquisition is basicly passive acoustic measurement. Various sound waves generated by fluid movement in dynamic condition will be captured by accoustic sensor. It is separated into two different frequencies : a. Ultra low frequency or narrowband spectrum (8 to 4,000 Hz), b. Wideband spectrum (8 to 60,000 Hz). High resolution of pressure temperature data surveillance is also acquired to provide a comprehensive pressure temperature behaviour in the area of interest and surrounding formation.

As the result, This paper includes two case studies that demonstrate the integration of accoustic ultrasound and pressure temperature surveillance can identify undesired flow behind casing caused by well integrity problem that is not detectable with conventional method such as cement bond log and production logging tools. The first case is an artificial lift well that was challenging in data acquisition technique and operation. Another case is a gas well with high undesired water production. The data interpretation and comprehensive study provides unpredictable source of water production precisely. The source of water production was coming from non perforated zone through behind casing, squeezed zone and the casing liner.

This study should be a valuable analysis to guide the remediation plan. The well production performance can be restored through proper remediation job. Moreover, this paper should be beneficial to help all engineers currently working in brown oilfield not only to identify the source of production problem precisely but also develop a comprehensive and effective workover program

Keyword(s): Ultrasound Leak Detection; Pressure Temperature Surveillance; Wellbore Flow Profile; Well Integrity; Workover

1. Introduction

In the ever-growing competitive market place in today's oil and gas industry, operators are proactively exploring new and improved means of working in a smarter manner and reducing operational costs. With this challenge the health of the well is a critical for sustained production and maximized recovery to exploit ever more difficult reserves. The ability to log behind casing promptly and accurately is a fundamental study to identify the quality of well integrity and reservoir flow allocation so that the aim of making smarter business decisions to ensure longevity of field life and optimal sustainable production performance can be achieved. This paper explores some of the challenges of Well Integrity and Reservoir Flow Allocation facing the industry and how the combination of sonic and temperature logging can provide Oil and Gas professionals to make an effective interpretations and decisions to restore the production performance.

2. Well Integrity Concern

Integrity remains at the forefront of well safety throughout the well's lifecycle, from drilling through to the latter stages of production or injection, plug-back, abandonment and decommissioning. The basis of well and completion integrity not only encapsulates safety but also the overall productivity of reservoir and well performance (it shows in figure 1 & 2). Several well integrity studies and surveys conducted in Well Prabu1 & Prabu2 need to revise its philosophy on barrier integrity. Monitoring isolation and running diagnostics when signs of failure manifest are essential for maintenance of a healthy well and production strategy. While conventional spinners and temperature logging can assess first barrier leak, there is a technology gap for measuring leaks that occurs behind first barrier or for identifying fluid movement between reservoirs that should be isolated. Fluid can move between such zones via cement channels, bypassing completion components or through the formation itself.

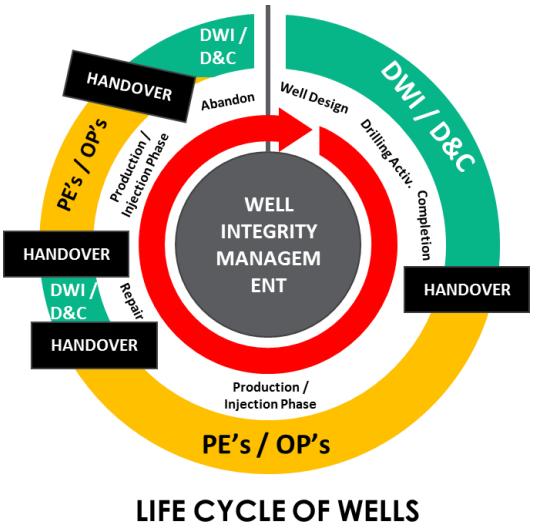


Figure 1. Life Cyclce of Wells Diagram

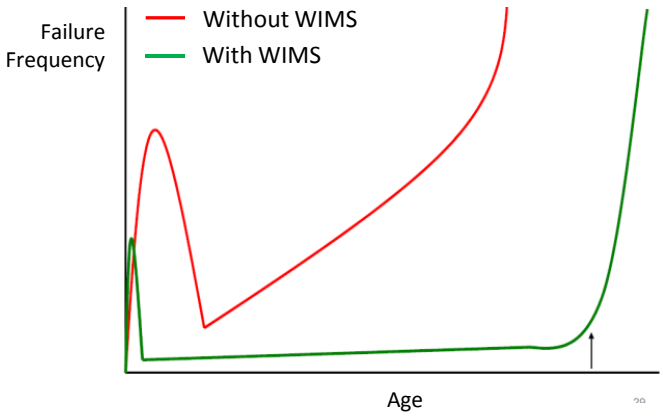


Figure 2. Well Integrity Impact to The Well (Failure Frequency vs Age)

2.1 Spectral Noise Logging for Well Integrity

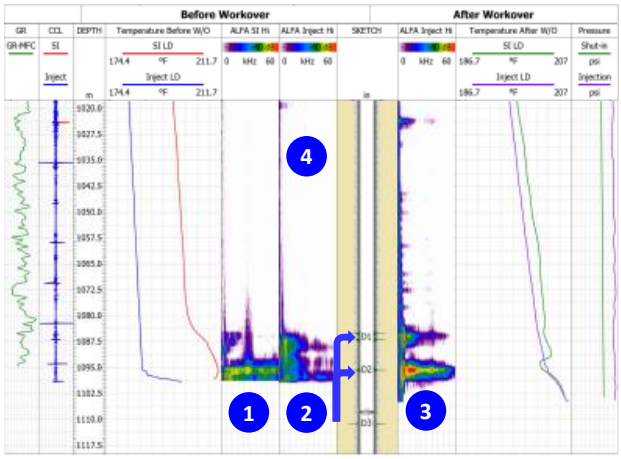
The latest generation of high bandwidth, high definition Spectral Noise Logging (SNL-HD) provides unprecedented investigation into the isolating status of completion components, identifying previously undetectable failures in tubing, GLM, packers, liner and behind casing leaks. Combining noise logging with temperature logging allows identification of various well component failures, diagnosing critical elements such as the source of sustained annuli pressure (SAP), and identifying complex or multiple annuli communications.

The Spectral Noise Log (SNL) combined with a temperature log provides the engineer with substantial information on the acoustic pattern of flow profile within the well. A typical SNL log gives the well intervention and reservoir engineers a plot of the noise spectrum intensity with depth indicating behind fluid flows, leaks and annulus communications. (See case study Well Prabu1 – figure 3).

2.1.1 Reservoir Flow Allocation (RFA) Case Study – Well Prabu1

Reservoir management is a complex process, with many challenges associated with uncertainties in reservoir dynamics, such as flow allocation and accurate material balance. When considering behind casing logging of a producer, it is unusual for the borehole (perforation) flow profile to represent that of the formation. The flow geometry behind the casing can be complex, where water bearing layers out-with the production perforation interval can contribute significant ***"unwanted water"*** flow via cement channels or near wellbore fractures. Likewise, oil and gas recovery measurements can be misleading.

Well Prabu1 is the biggest oil production well in eastern area of Prabumulih Field with an average water oil ratio 78% during 2021. The water oil ratio increase rapidly on August 2021 from 78% to 100% then well Prabu1 was shut-off. Reservoir and production engineers might conclude and propose that the casing damage upper the perforation zone is the source of water based on well services historical data. A SNL combine Pressure - Temperature log challenges this conclusion as it is clear that water bearing layers out-with the production perforation contribute significant "unwanted water" flow via cement channels (It shows in Figure 3). Without this additional interpretation, an effective work over solution would not have been identified.



1. During Shut in period, there was a crossflow between water bearing zone D3 to the production perforation D1 & D2, Pressure & Temperature log was also confirmed.
2. During Injection period, a crossflow between water bearing zone D3 to the production perforation D1 & D2 becoming more massive.
3. After Workover job (re-mediation & re-perforation) flow distribution in the production zone is ideal and there is no crossflow behind the casing
4. It is clear that there was no flow out-with casing damage interval

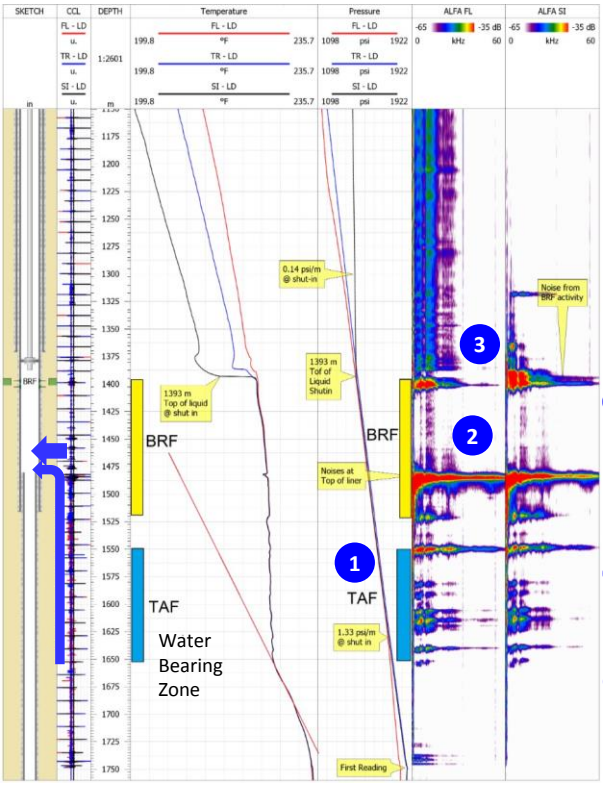
Figure 3. Log Track from Left to Right – Gamma Ray, CCL, Depth, Temperature Profile, SNL Shut in Profile, SNL Injection Profile, Well Schematic

The well performance can be restored after proper workover and remediation job. The water oil ratio can be decreased from 100% to 80% in average and oil cummulative production can reach 5,720 STB (it shows in Figure 5).

2.1.2 Reservoir Flow Confirmation (RFC) Case Study – Well Prabu2

SNL profile not only seeks to mitigate the effects of reservoir flows uncertainties but also focuses on answering and confirm how each layer in the well can contribute to total production. Case study – well Prabu2 needs to revise its philosophy on the importance of barrier integrity to the well performance prediction.

Well Prabu2 is a new infill gas well drilled on 2021 in the top structure of Baturaja limestone. The well was completed as directional well with a production casing combine 9 5/8" casing and 7" liner. Structurally, Well Prabu2 was completed in the top of Baturaja limestone compared to the existing surrounding wells which is currently still producing with an average rate 4-5 mmscfd of dry gas. But in contrastly, the result of production test well Prabu2 is not meet the target according to the existing surrounding wells. A SNL combine Pressure - Temperature log challenges this problem as it is clear that water bearing layers out-with the production perforation contribute significant "unwanted water" flow via 7" liner (It shows in Figure 4).



1. During Shut-in and dynamic condition indicates there is a fluid movement from water bearing zone (TAF) out-with the production zone (BRF) via Top Of Liner (TOL), pressure and temperature profile is also confirm.
2. During Shut-in and dynamic condition indicates a leaking in TOL with a high intensity movements.
3. Pressure profile during Shut in period indicates there is difference pressure recorded in accordance to the surrounding existing wells.

Figure 4. Log Track from Left to Right – Well Schematic, CCL, Depth, Temperature Profile, Pressure Profile, SNL Shut in Profile, SNL Injection Profile

The well performance can be restored after proper workover and remediation job in the 7" liner. The gas production rate can be increased from 0.18 to 2.9 mmscfd in average and gas cummulative production can reach 250 MMSCF (it shows in Figure 5.).

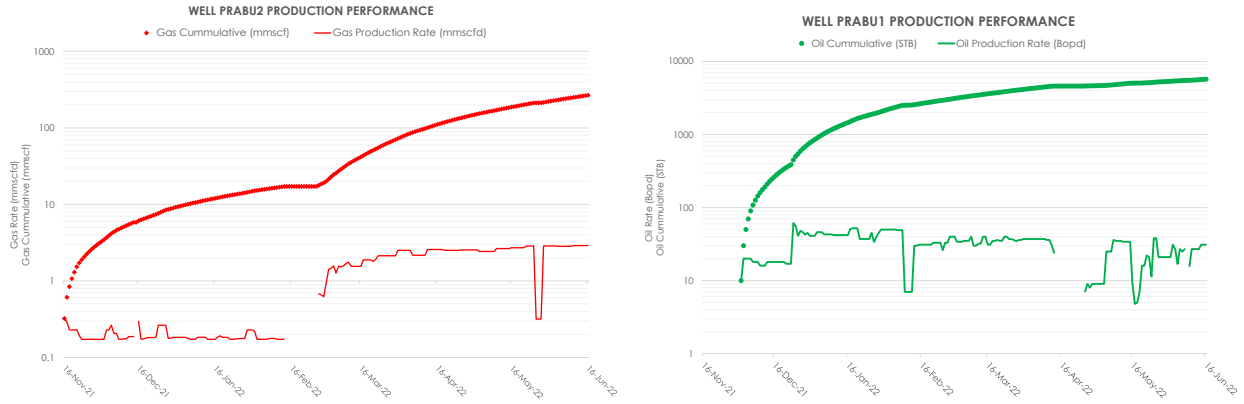


Figure 5. Production Performance Well Prabu1 & Well Prabu2.
(Rate Production & Cummulative)

3. Summary & Conclusion

Evidently the changing economic landscape has and will continue to force the oil and gas industry and related businesses to explore the full advantage of the technological tools available and their importance under various applications to address industry issues. As can be clearly concluded proper well integrity monitoring is paramount in preventing failures and accidents at wellsite. The effectiveness of leak detection methodology of combining High Precision Temperature and Spectral Noise Logging (HPT-SNL) not only can monitor processes behind the casing, enabling and ensuring identification of leaks in the tubing, casing and behind casing but also can be utilized in a different application and mode to reveal the insightful information related to the reservoir flow allocation (RFA) such as: source of ***"unwanted water"***, identification of thief zones, and identification of any opportunities bypassed hydrocarbon that can be additional revenue. The addition of Spectral Noise Logging aids in the understanding of the true inflow profiles of producer wells and injection profiles of injector wells operating in an asset, the information is critical for production engineers, reservoir engineers and well intervention engineers alike.

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