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Analysis of Cementing Wells X-1 and Y-1 Using Multifunction Ultrasonic Imaging Logging Tool

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ABSTRACT

By analyzing the measurement principle of the ultrasonic pulse method, a multifunctional ultrasonic image recording device and the application of the measurement technique were designed. It can perform surface imaging well in high-resolution imaging mode in open holes. Can also perform casing inspection and cement bond evaluation in full wave mode at casing holes. The proposed tool was tested in practice. This shows that this tool can evaluate geological feature information such as fractures and layered structures in open holes. Imaging casing thickness, inner and outer diameters and cement impedance can also be measured at casing holes. Cement analysis in wells Logging Tool (MUIL), cement slurry design and operations during cementing. The logging results above can be analyzed quantitatively including amplitude readings which can then determine compressive strength prices and bond index prices. Meanwhile, qualitative analysis was carried out comprehensively from VDL recordings and using the Enhanced Logging Imaging System. For analysis from a design perspective, it looks at the cement slurry planning, while from an operational perspective it looks at the suitability between planning and implementation in the field.

Keywords: bond index, hydraulic seal, isolation zone, re-cementing

I. INTRODUCTION

Analysis of cement results is a series of activities that need to be carried out to determine whether a cement bond is good or bad. The function of cement is very important, because the success of the cement results affects the hydrocarbon fluid production process. Therefore, it is necessary to evaluate the cement results so that in the future when production is carried out there are no problems, such as leaking casing, contamination of the drilling fluid with the formation and so on. The results of this evaluation can be used to draw conclusions about whether remedial cementing action is necessary or not. Previous research was only limited to logging tools, namely Cement Bond Log (CBL) and Segmented Bond Tool (SBT) carried out by Faisal E. Yazid, 2015. Evaluation of cementation results was carried out to obtain cementation results that met the requirements in accordance with the provisions of the Standard American Petroleum Association Cement.

Cementing an oil well involves pumping cement into the annular space between the casing and the formation after drilling to connect them and thereby isolate the reservoir during production. The quality of cementation is clearly very important for the safety of production in oil fields. Acoustic logging is a widely used method to evaluate cement quality. To date, commonly used cement quality recording methods include Cement Bond Logging (CBL), which uses high wave amplitude, and Segmented Bond Tool (SBT), which is based on high wave attenuation ratio. However, CBL results represent the average contribution to cementation quality in all circumferential directions and thus cannot assess cementation quality in a particular direction. Although SBT resolution is circumferential, this method is influenced by the position of the casing in the wellbore.

Cementing results that meet standards must be able to produce good cement bonding, compressive strength that is resistant to pressure from the formation and from within the casing and most importantly the function of the cement itself can be fulfilled. Evaluation of the results of cementing the X-1 and Y-1 drill holes is intended to determine the strength and adhesion of the cement. This analysis prioritizes productive zones. Cement will be useful as a perforation medium if the perforation point is a transportation route for hydrocarbon fluid to the surface. If the results of the well evaluation show indications that the pipe is free, has channels or does not have good adhesion and cement strength, then corrective action must be taken by means of cementing. Analysis and evaluation of cement results is carried out by analyzing cement results in the well - MUIL (Multifunction Ultrasonic Imaging Logging Tool) with Elis software. Based on the CCL-GR-CBL-VDL-MUIL measurement results, differences in cement bond properties between reservoir wells.

II. METHODS

The research method used was to conduct a literature study on several literatures related to cementing and bond index analysis. Primary data is CCL-GR-CBL-VDL-MUIL logging data, while secondary data collected includes cement data, well data and production zone data. The research stage begins with determining the parameters used in bond index analysis based on cement and cement theory. This parameter is determined to determine the classification or limitations in assessing whether the research results are good or bad. After that, data collection is carried out where the initial data is data that comes from the interpretation of logging data. From the interpretation of the logging data, the CBL value and attenuation rate value are obtained. To get the bond index value, do calculations based on the bond index value formula and Elis software. Required well data (Well data collection):

- Casing information: casing ID, casing OD, casing grade
- Casing tally
- Well fluid data: fluid weight
- Well survey
- Well sketch
- Cement report
- Correlation curves

The MUIL consists of two parts: the scanner assembly and the electronics assembly. The scanner assembly mainly consists of a motor, slip ring, transmission shaft, rotating scanner head, hydraulic balancing system and acoustic transducer, and is used for ultrasonic scanning of the borehole wall; The electronic assembly provides the excitation source of the converter and the control circuit for the rotating motor and is responsible for acquiring and processing the acoustic signals received from the converter.

The MUIL acoustic transducer has self-transmitting and self-receiving functions, and the electronic circuit excitation transducer transmits ultrasonic pulse signals during the logging process. The acoustic pulse signal penetrates the well fluid into the inner wall of the casing. Most of the acoustic energy results in reflection on the inner wall of the housing, the reflected acoustic signal is received by the transducer, and its amplitude and transit time are sent to the ground software after being detected and processed by the electronic circuit for imaging visualization, so that the corrosion distortion of the inner wall of the housing can be detected and evaluated visually and precisely. Meanwhile, some of the ultrasonic waves that meet the casing resonance conditions penetrate the inner walls of the casing and are reflected back and forth between the inner walls of the casing and the outer casing cement, and some of the ultrasonic signals are received by the transducer. is called a casing resonance wave. Through full-wave acquisition and spectral analysis and processing of casing resonance waves, and based on the correlation between acoustic impedance and resonance wave energy, information about casing thickness and acoustic impedance parameters of materials outside the casing can be obtained. cement bond quality outside the casing can be done.

Based on the measurement principle of the ultrasonic pulse method, a multifunctional ultrasonic image recording device has been developed and explained how it works. It can perform drilling hole wall imaging with open hole high-resolution imaging mode. Additionally, full-wave mode can be used to perform casing inspections and cement bond evaluations in casing holes. Tools that can be tested on open holes and cased holes. The results show that this tool can evaluate geological feature information such as fractures, holes and bedding structures in open holes. Imaging casing thickness, inner and outer diameters and cement impedance can also be measured in the casing hole. This tool can provide a quantitative assessment of casing corrosion and cement bond quality.

Multi-function ultrasonic imaging tool MUIL (MUIL multi-function imaging instrument) uses the instrument's rotary scanning method to collect media information on the longitudinal and radial well walls of the borehole, and produces 2D images of the inner wall, outer wall and cement quality through the process imaging.

a) Instrument composition

Electronic circuit + Ultrasonic rotating probe

b) Instrument characteristics

Casing damage detection and cement quality measurement can be completed in one downhole operation. Probes of different sizes and frequencies can meet different string size requirements.

c) Working conditions

Bore hole diameter: 7.0 in - 9.625 in

Applicable pipe wall thickness range: 5.0 mm ~ 16.0 mm

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d) Technical parameters

Hold temperature: 175°C (350°F)

Withstanding pressure: 137.9 Mpa (20000 Psi)

Instrument outer diameter: 92mm (3.63in)

Instrument connection length: 3911mm (154.0 in)

Total instrument weight: 98 kg (216 lb)

Maximum measurement speed: 3m/min (10 ft/min)

Wall thickness measurement range: 5.0 mm ~ 16.0 mm

Measurement accuracy: Azimuth accuracy: 6° Wall thickness accuracy: ±6%

Resolution: Longitudinal resolution 1.5in Wall thickness resolution 0.1mm

Acoustic impedance resolution 0. 2 Mrayl

e) Data quality control criteria

1. Instrument performance check
   - The probe model requires that the center frequency of the probe must match the thickness of the casing to be measured.
   - The selected centering must correspond to the measured casing size.
   - The scanning head of the probe must rotate normally, and can record the waveform (reflected wave, resonant wave) integrally and clearly
   - Various instrument inspections must be detailed and complete.

2. Requirements on the curve

   The control localization curve must be changed clearly, and the shear sleeve, packer, and other downhole tools must be clearly characterized. The natural gamma ray curve requires that the shape of the repeated measurement curves be substantially the same as each other with a relative error of 5% and a relative error of statistical fluctuation of less than 3%. The waveform curve requires that the waveform curve can record the reflected wave and the resonant waveform integrally and clearly. In the undamaged position spectrum analysis chart, the leakage peak is in good condition. The reflected wave timing imaging and the reflected wave amplitude imaging must be clear and both must be consistent.

3. Repeatability check
4. Construction recording requirements
5. Tool inspection on site (Tool inspection on site)

The MUIL multi-function ultrasonic imaging tool uses the instrument's rotary scanning method to collect media information on the longitudinal and radial well walls of the drill hole, and produces 2D images of the inner wall, outer wall and cementing quality through the imaging process.

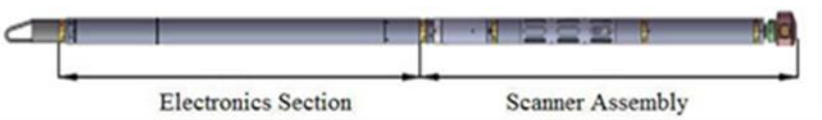

Figure 1. Sketch of the MUIL instrument

The MUIL instrument mainly consists of electronic parts and a scanner assembly, as shown in figure 1. The electronic sub-assembly is responsible for powering the transducer and processing tool commands from the surface logging system. The scanner sub-assembly contains two ultrasonic transducers: one is a mud cell transducer; another is a measurement transducer. Mud cell transducers are used to measure borehole fluid velocities. The measurement transducer, which is faxed in the rotating scanner head, transmits ultrasonic impulses and then switches to receiving mode. The normal range of casing thickness is about 4.5 mm to 15 mm in oil production, and this corresponds to a fundamental frequency range of 160 kHz to 600 kHz. Because transducer frequencies are limited, it is difficult to cover this wide range using a single transducer. So have designed three different frequency transducers (250 kHz, 350 kHz, 450 kHz) to cover the casing thickness range. Also, a kind of focusing transducer has been designed whose center frequency is 380 kHz. It can be used to take borehole wall measurements.

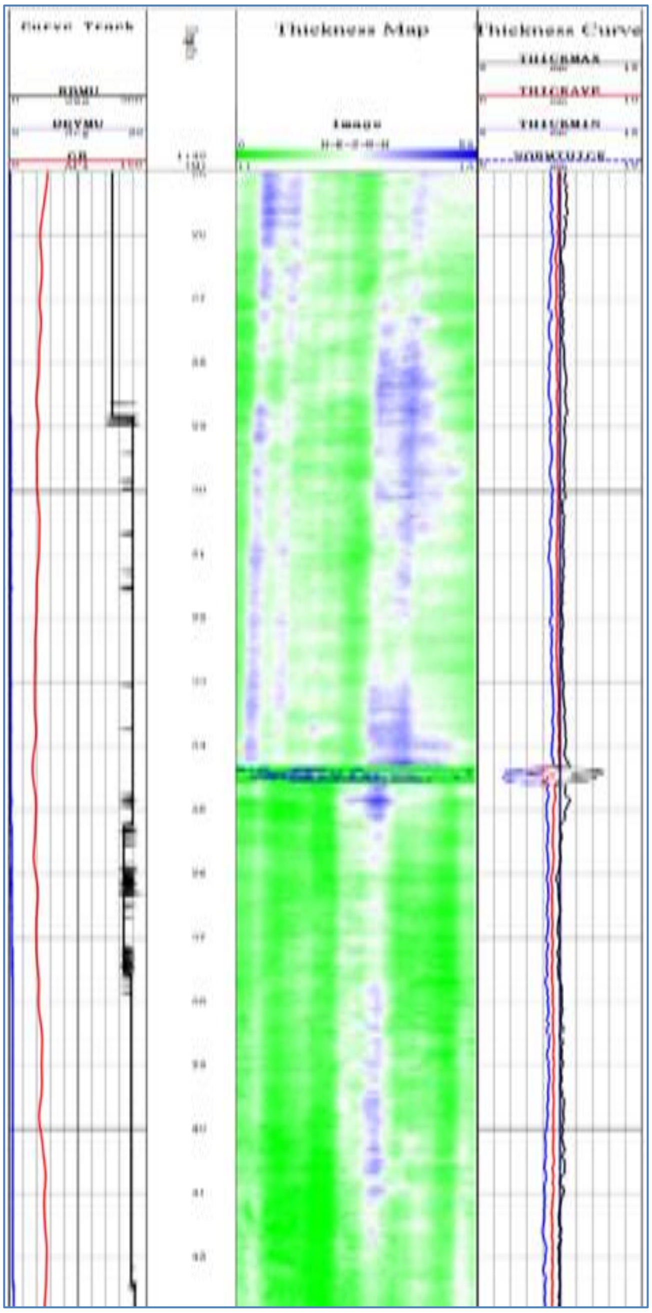

Figure 2. Casing Inspection Evaluation Results

Image Caption 2.

1. The green color appearance on the pipe has some corrosion. The thickness of the pipe changes slightly thinner

2. The blue color appearance on the pipe has some corrosion. The thickness of the pipe changes slightly thicker

The multifunctional ultrasonic image recorder can perform casing inspection and cement bond evaluation using ultrasonic pulse echo techniques. The internal condition of the housing can be checked using echo amplitude and transit time curves. Casing thickness and cement impedance can be calculated from the resonant frequency and resonance dip. This article describes two case studies of housing inspections with this instrument in detail. The first case reports evaluation of the perforation interval in a sheathed hole; The increase in perforation intervals, holes and perforations, can be seen from the echo amplitude and radius imaging curve in the housing. In the second case, we cannot see any corrosion or deposits on the casing thickness mapping curve, but the echo amplitude and travel time curves characterize some deposits on the casing surface.

III. RESULTS AND DISCUSSION

3.1. Explanation of Research Results

The MUIL instrument has been tested on open holes and cased-holes in the field. Figure 1 shows the results of MUIL instrument measurements in several open holes. The amplitude curve and transit time curve of the reflected wave are plotted on this figure. The richness of geological structure information can be seen from this measurement section, where the amplitude curve and transit time curve show clear differences between the depth range of 2350 m~2356 m and other sections. This difference actually reflects changes in formation lithology. Throughout the measurement range, the imaging curve is clearly visible within a certain rule. There are some smooth sinusoidal curves, which are typical of bed flags. At a depth of 2361m in this well, some round white spots can also be observed on the amplitude curve, indicating the echo amplitude here is very weak. While the transit time curve shows a black dot, it indicates that the echo came later.

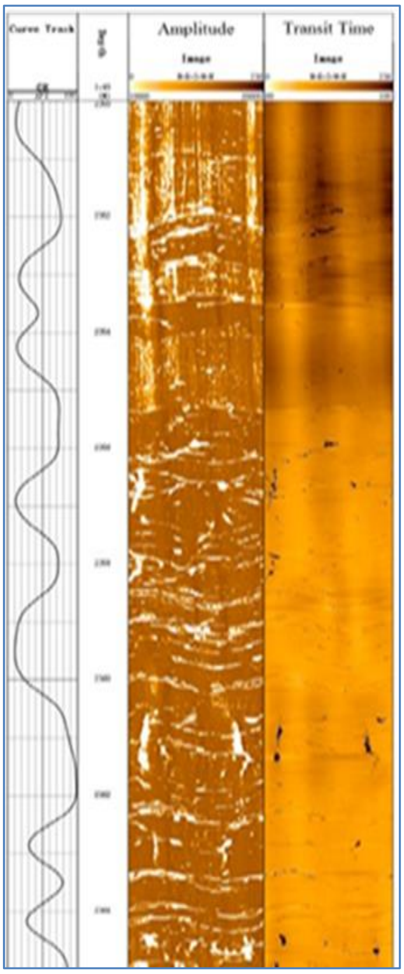

Figure 3. Example of Borehole Surface Imaging for Open Hole

Figure 4 shows the measurement results of the MUIL tool on several cased holes. Track 2 shows the amplitude image map. Track 3 shows an image map of transit times. Track 4 shows the maximum internal curve, minimum internal radius curve, and average internal radius curve. Track 5 shows the internal radius image map. Track 6 shows the external radius image map. Track 7 shows the maximum thickness curve, minimum thickness curve, and average thickness curve. Track 8 shows the thickness image map. Track 9 shows the average cement impedance curve. Track 10 shows the cement impedance image map. This shows that the inner surface of the casing is very smooth and there is no corrosion in this measuring section from track 2 to track 4. However, at the section depth of 1352m~1362m, the inner radius image map has no change, but the thickness image map and external radius image map show casing damage. And the difference in casing thickness between the maximum value and the minimum value is around 3mm, this indicates the presence of corrosion and deposits on the outer surface of the casing. Since the average impedance value of cement is about 3M Rayls, the cement bond quality is not very good. This indicates that there are some solids at several azimuths in this well.

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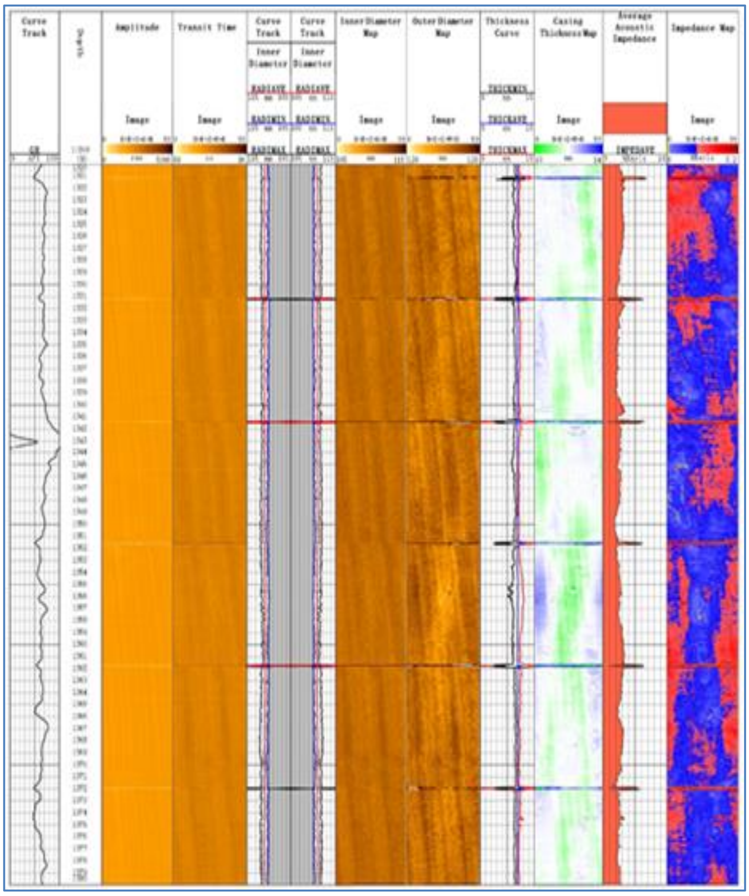

Figure 4. Example of Borehole Surface Imaging for Cased Hole

The results obtained from the ELIS data processing software and its flow chart for the CCL-GR-CBL-VDL-MUIL log recording of the Wells X-1 and Y-1 are presented as follows:

Well X-1:

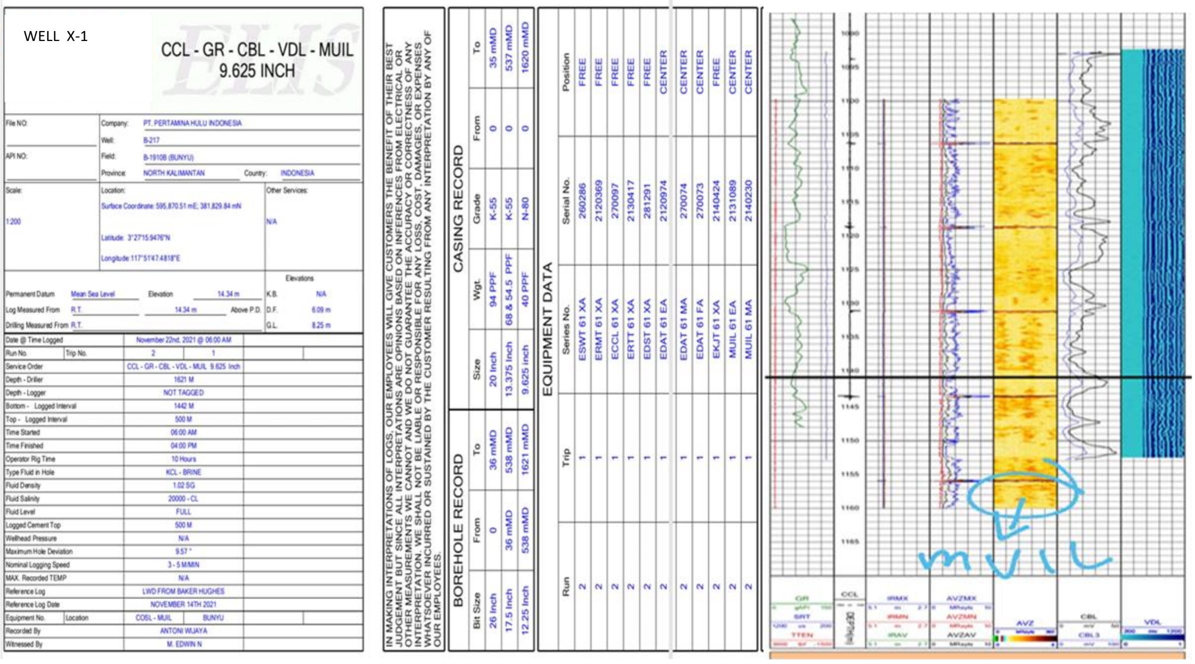

Figure 5. Logging Record of CCL-GR-CBL-VDL-MUIL for Well X-1

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Well Y-1:

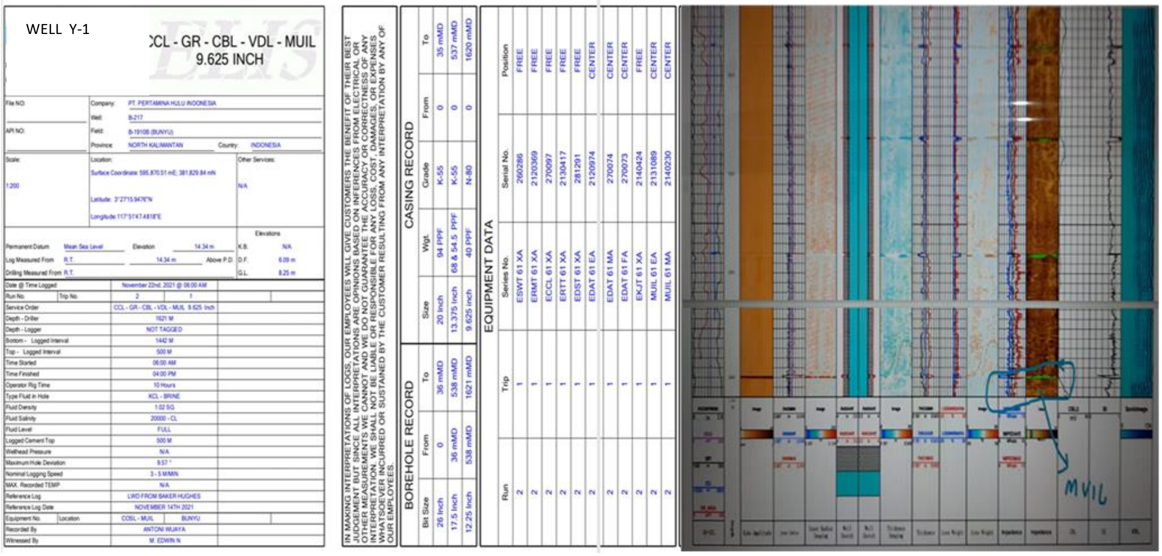

Figure 6. Interpretation of Logging CCL-GR-CBL-VDL-MUIL Well Y-1

The binding index value is determined after obtaining the CBL value from the logging records in Figure 4 and recording the attenuation level value. The bond index refers to the bond state of the cement to the casing and provides an idea of the cementation results. It is calculated using the following formula (Nelson, 1990):

$$BI(x) = \frac{A(x)\ (dB/ft)}{A\ (100\%)\ (dB/ft)\ (dB/ft)} \quad (1)$$

Description: BI : Bond Index

A(x): Attenuation in the zone of interest

A(100%) : Attenuation in the perfectly cemented zone

Interpretation Results for Bond Index Value

Table 1. Well Y-1 Bond Index Data

Depth (meter)	Nilai CBL (Mv)	Nilai Attenuation Rate	Nilai Bond Index
1587	10	5.84	0.404993065
1597	4	8.46	0.58668516
1599	1	12.42	0.861303745
1610	0.5	14.42	1
2172	0.5	10.46	1
2178	1	10.46	0.861303745
2183	2	10.46	0.725381415
2194	2	10.46	0.725381415
2516	2	10.46	0.725381415
2518	2	10.46	0.725381415
2640	2	10.46	0.725381415

The bond index formula led to the following assumption:

a. Attenuation in a perfectly cemented zone can be determined by assuming that the depth with the lowest CBL logging value [19] or the highest attenuation level is the perfectly cemented zone (100%).

b. Table 1 shows that the lowest CBL logging value reading was 0.5 mv or the highest attenuation rate was 14.42 dB/ft at a depth of 1610 meters. The CBL value showed that the bond index = 1, indicating 100% bonding.

Calculated Bonding Index (BI) = 0,725381415

Logging interpretation results from CCL-GR-CBL-VDL-MUIL = 0,6

Deviation 1 = ((0,725381415 – 0,6)/ 0,6) x 100 %

= 20,897 %

Deviation 2 = ((0,725381415 – 0,6)/ 0,725381415) x 100 %

= 17,285 %

3.2. Analysis

X-1 and Y-1 are development wells in the Bunyu Field owned by PT Pertamina EP (PEP) in the Kalimantan Regional Hulu Holding Zone 10. and Logging Interval Lower 1442 M MD, while Y-1 is drilled with the same orientation but 26.42 degrees, respectively 1570 M MD and 2650 M MD. The two wells are located in Bunyu District, Bulungan Regency, North Kalimantan Province. Cement bond was analyzed at different depths, namely 1160 m CCL for X-1 using CCL-GR-CBL-VDL-MUIL and 2640 m for Y-1 using CCL-GR-CBL-VDL-MUIL. CBL analysis along the 7 inch casing depth for the wellbore exceeded 30 mV and strong casing and formation arrivals were reported for the SBT wave. Additionally, cement was analyzed along the 7inch depth casing liner for the Y-1 well using CCL-GR-CBL-VDL-MUIL, focusing on amplitude, attenuation, cement maps and SBT waves. The results showed that most of the liners had poor cement bonding, which was indicated by amplitude values above 20 mV and attenuation values less than 2 dB/ft. This means that the primary cement in well Y-1 has poor bond quality, while well X-1 has good quality.

The lithology of the two wells was the same and this led to the expectation of a similar cementing quality but the observation was different as indicated by the result. The quality of primary cement usually depends on factors such as cement design and operation. The slurry design is a major factor in determining the quality of cement and is usually required to be in accordance with the American Petroleum Institute (API) standard with a focus on physical properties such as density, filtration loss, free water, thickening time, and compressive strength. The result showed that Wells X-1 and Y-1 had only tail slurry with a density of 1.9 SG (5.66 Mrayl) due to the large formation pressure and siting in an area being considered for perforation. This density value was discovered to be in accordance with the API standards.

The parameters of Wells X-1 and Y-1 were discovered to be in accordance with the required standards or criteria. The two wells were expected to produce similar cement bond quality because they had the same formation and technically received the same treatment in the form of slurry design and additives used. However, the results showed that only Well X-1 had good cement bonds along the 7" casing liner while Well Y-1 mainly exhibited bad bonds. In addition to the previous explanations, several other factors were suspected to be the cause of the poor cement bonding in Well Y-1. These include failure to calibrate tools before use, the inability of the slurry cement behind the casing to dry completely before the CBL logging tool was applied, easy damage of cement material in well conditions, as well as the unpredictable partial loss of cement to formation due to the existence of several layers of potential, porous, and permeable sand. Some others include the occurrence of flash set when the liquid cement slurry (free water) entered the permeable layer which made the slurry thickness not to be homogeneous, breakage of the formation due to the presence of higher slurry density compared to its pressure, migration of gas, and an inexperienced crew.

IV. CONCLUSION

Based on the results of the discussion previously presented, several conclusions were obtained, namely as follows:

1. From the results of the CCL-GR-CBL-VDL-MUIL analysis, well X-1 mostly has a good cement bond (good bond) with an average amplitude below 20 mV while well Y1 mostly has a bad cement bond (bad bond).) with an average amplitude above 20 mV.
2. In the Y-1 well, the interval is to a depth of 1587 – 1597 m, 1599 – 1610 m, an indication of free pipe, 2172 – 2178 m. 2183 – 2194 m indication of bad to formation, 2516 – 2518 m indication of channeling. This well was considered to be poorly cemented or problematic because CCL-GR-CBL-VDL-MUIL rerun logging was not carried out.
3. The parameters evaluated, such as the amount of slurry volume, thickening time, filtration loss, free water, cement flow lane and spacers, are in accordance with the criteria.
4. From the results of the Bond Index calculation using the formula compared with the results of the CCL-GR-CBL-VDL-MUIL interpretation, there is a significant deviation of around 20%.

Suggestions for further cementing activities are to calibrate the tool before use, ensure that the cement is completely dry before the CCL-GR-CBL-VDL-MUIL is run, use cement whose density is appropriate to the formation pressure and also suitable to the formation conditions, predict there is gas migration, more attention to drill parameters, and the crew is given training.

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REFERENCES

American Petroleum Institute. (2002). API Specification 10A. “Specification for well cements and Materials for Well Cementing” Twenty-Third Edition. Washing-ton, D.C., USA.

Cementlog – Crain’s Petrophysical Handbook (2012). (http://www.spec2000.net/07-cementlog1.htm), diakses April 2012

Cement Bon Log -Wikipedia (2012). (http://en.wikipedia.org/wiki/ Cement_bond_log), diakses Oktober 2012.

Dowell Schlumberger : “Cementing Technology“, 1983.

Faisal E. Yazid, et.al, “Evaluasi Penyemenan Casing Liner 7” Pada Sumur X-1 Dan Y-1 Blok LMG, Seminar Nasional Cendekiawan 2015

Fuad, M. (2006). Sumur T-X PT. Pertamina Ubeb Tanjung. Intrepetasi CBL-VDL, Elnusa Drillling Services. Tanjung : PT. Pertamina Ubeb Tanjung.

Halliburton : “Sales and Services Catalog“, Halliburton Company, Duncan ,1983.

Hendy, P. (2007). Sumur SMG-X PT. Pertamina EP Region Jawa Area Cepu. Intrepetasi CBL, Elnusa Drillling Services. Cepu : PT. Pertamina EP Region Jawa Area Cepu.

Mian, M.A. (1992). “Petroleum Engineering Handbook For The Practicing Engineer”. Vol.II. Oklahoma: Pennwell Publishing Company

Nelson, Erik B. (1990). “Well Cementing”. Texas: Schlumberger Education Services.

Rubiandini, Rudi. (2012). “Teknik Operasi Pemboran” . Vol.1. Bandung: Penerbit ITB.

WellTech-COSL: “Enhanced Logging Imaging System (II)”, www.cosl.com.cn