Identification of Cementing Quality and Hydraulic Seal at Hydrocarbon Zone in F Field

(Identifikasi Kualitas Semen Dan Penyekat Hidrolik Pada Zona Hidrokarbon Di Lapangan F)

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Abstract

Cement analysis needs to be done on wells that have decreased production and there is additional water production. The longer the well is produced, the water will approach and even reach the perforation zone which results in the water being produced. Several steps must be proposed in knowing and handling water production in wells, in addition to collecting data from wells and reservoirs in full, analysis of problems related to mechanics such as cementing analysis needs to be done to determine the possibility of leakage, microannulus or channeling. The method used is quantitative, by comparing the amount of water production in two wells and its relation to the hydraulic seal formed in the cement. The analysis was carried out on two wells, namely F-3 and F-4. F-3 wells produce large amounts of water, namely 1168 BWPD. This is possible considering the position of this well adjacent to the water zone. And based on the analysis carried out, the hydraulic seal on the F-3 well has not yet been formed making it possible for direct contact between the productive zone and the water zone. Water production in F-4 wells is 35 BWPD. The low water production in these wells can also be assumed due to the formation of hydraulic seals in cementing. Looking at the data above, it can be concluded that without the formation of hydraulic seals on the F-3 wells, secondary cementing needs to be done to close the cementing which is not good so that there is no leakage anymore and there is no communication between the productive zone and the water zone.

Keywords: CBL, VDL, Cementing, Hydraulic Seal, Formation

Sari

Analisis semen perlu dilakukan pada sumur yang mengalami penurunan produksi dan terdapat penambahan produksi air. Semakin lama sumur diproduksi maka air akan mendekati bahkan mencapai zona perforasi yang berakibat pada air yang dihasilkan. Beberapa langkah yang harus diusulkan dalam mengetahui dan menangani produksi air di sumur, selain pendataan dari sumur dan waduk secara lengkap, perlu dilakukan analisis permasalahan yang terkait dengan mekanika seperti analisis penyemenan untuk mengetahui kemungkinan kebocoran, saluran mikro atau penyaluran. Metode yang digunakan adalah kuantitatif, dengan membandingkan jumlah produksi air di dua sumur dan hubungannya dengan hydraulic seal yang terbentuk di dalam semen. Analisis dilakukan pada dua sumur yaitu F-3 dan F-4. Sumur F-3 menghasilkan air dalam jumlah besar yaitu 1168 BWPD. Hal ini dimungkinkan mengingat letak sumur ini berdekatan dengan zona perairan. Dan berdasarkan analisis yang dilakukan, seal hidrolik pada sumur F-3 belum terbentuk sehingga memungkinkan terjadinya kontak langsung antara zona produkif dengan zona perairan. Produksi air di sumur F-4 adalah 35 BWPD. Produksi air yang rendah di sumur-sumur ini juga dapat diusulkan karena pembentukan segel hidrolik dalam penyemenan. Melihat data diatas dapat disimpulkan bahwa tanpa terbentuknya hydraulic seal pada sumur F-3 perlu dilakukan secondary cementing untuk menutup cementing yang kurang baik agar tidak terjadi kebocoran lagi dan tidak ada komunikasi. antara zona produkif dan zona perairan...

Kata-kata kunci: CBL, VDL, Penyemenan, Penyekat Hidrolik, Formasi

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I. INTRODUCTION

Cement is one of the most important processes in drilling. The aim can be to isolate zones that have different pressure or zones with high airflow, prevent leakage of liquid to the surface, prevent rusty sheaths, and more. Cement is divided into two, namely primary cement, which is the first cement after drilling, and secondary cement, which is cement intended to restore the first cement. Some problems that occur during drilling are also possible to influence cementing. The problem is most likely to be a problem with the formation, which can cause the cement to disappear into the formation or the cement does not have a good bond with the formation. Another problem is that the cement bond is not strong enough to prevent leakage. This cement bond can be done through Cement Bond (CBL) and Variable Density Log (VDL) logs. Effective zone isolation between permeable intervals in a well needs a cement sheath
over an considerable vertical interval. It is necessary for the annular cement sheath to provide an effective hydraulic seal to withstand subsequent completion and production operations [1].

Cementing is a series of activities carried out to fill the space between the casing with the borehole wall with cement slurry or slurry. The pulp will be left to harden and become a binder between the wall of the borehole and the casing. The cementing work is divided into two. Cementing that can be done after installing the casing is commonly called primary cementing. While cementing other than primary cement or cementing which is done after the well is produced is called secondary cement [8].

The function of cementing is to prevent fluids from migrating from one layer to another, protect the casing of corrosion, prevent mechanical problems due to vibration and maintain the possibility of collapse at the bottom of the well [5]. The purpose of this research is to find out whether the water produced is due to poor cementing or because of other problems that can affect production. According to the literature [7], several stages must be proposed in knowing and handling water production in wells. In addition to collecting data from wells and reservoirs in full, an analysis of problems related to mechanics such as cementing analysis needs to be done to determine the possibility of leakage, microannulus, or channeling. Looking at the production data above, the discussion will focus on analyzing the quality of cement in the 7-inch casing where the flower zone is located to find out what water production is caused by bad cement so that it cannot hold water from the formation. Cementing quality is done by looking at the results of the bond index. A bond index of less than 0.8 is indicated as the cement of poor quality or the casing is not cemented completely, while a bond index of greater than 0.8 indicates that cement has good quality and bond [3]. Cement hardening will also form a hydraulic seal that will prevent fluid migration or isolate the zone [2]. The formation of a hydraulic seal is marked with a bond index with a value greater than or equal to 0.8 with a minimum interval of 3 meters [9].

Besides, at the cementing stage, it is important to prevent cement from contaminating the mud to prevent changes in the physical properties of cement [10]. These physical changes in cement can result in unsuitable cement quality as desired. Before pumping the cement, spacers are used to separate the drilling fluid from the cement slurry. With this separation, the cement will not be contaminated with drilling fluid and the casing or formation will be water-wet. With the surface of the casing and the formation that is water-wet, the cement will be able to stick well to the casing and the formation so that there is no gap for the fluid to flow to the surface or direct contact between the permeable zones can be avoided [9]. The use of spacers is recommended to have a turbulent flow to facilitate the cleaning of the mud cake. Then contact time also needs to be considered when using spacers. The recommended contact time is 8 to 10 minutes to maximize drilling fluid displacement [6].

II. METHOD

The study was conducted with quantitative methods, namely, research conducted systematically and structured.

The study was conducted by reading the CBL and VDL logs and analyzing the bond index, compressive strength, and seeing whether or not a hydraulic seal was formed as shown in Figure 1.

After knowing the results of the CBL, VDL, and bond index readings, which can determine the hydraulic seal, the quality of the cement can be interpreted.

III. RESULTS AND DISCUSSION

Cementing analysis was carried out on 2 wells located in the F Field located in the North Sumatra Basin, namely F-3 and F-4. The wells produce gas. In F-3 wells, fluid is produced from the UK-4, UK-5, and UK-C2B formations. This well-produced 2.9 MMSCFD, 1168 BWPD, 0.4 BCPD on a commingle basis from the two formations. Whereas in F-4 wells the UK-5 formation is 5.9 MMSCFD, 35 BWPD, 208 BCPD and in the UK-C2B formation is 6.4 MMSCFD, 32 BWPD, 294 BCPD. Based on these data it can be seen that the F-3 well has excess water production. It is feared that this excess water production is due to poor cementing quality which makes it possible for water to flow from behind the case to the production zone. Bond Index calculation will be carried out with the following formula (Safriza, Insyirah; Amin, M; n.d)

$$\text{Bond Index} = \frac{B_{l_i}}{B_{l_{\text{max}}}} \quad (1)$$

The configuration of the attenuation to compressive strength is done using the Cement Bond Log chart from Halliburton [4]. The first CBL and VDL log analysis was carried out on the F-3 well, which had a considerable amount of water production, in the UK-4 formation. Figure 2 shows the results of CBL and VDL logging in F-3 well formation UK-4.

Table 1 is a table showing the results of the calculation of bond index and compressive strength, where depth is in units of ft, amplitude in units of mV, attenuation in units of dB / ft, and compressive strength in units of psi.

According to one study, a good bond index is
80% while a smaller bond index can indicate cementation of poor quality or contamination with cement. In addition, other studies show that BI below 80% indicates that a hydraulic seal was not formed making it possible to indicate the presence of water flowing from behind the case. The quality of cementing UK-5 formations in F-3 wells can be seen in Figure 3.

Figure 2. CBL and VDL Logging on F-3, UK-4 Formation

Figure 3 is the logging result of the UK-5 formation with the depth of the perforation is 5,758 - 5,768 ft. Based on the results of the log, cementing has good quality, marked by a small amplitude. To prove the quality of cement bonds, the results of bond index analysis and compressive strength in the UK-5 formation can be seen in Table 2.

Table 1. Analysis of Bond Index and Compressive Strength on F-3 well, UK-4 formation

| Depth (ft) | Amplitude (mV) | Att. dB | BI | Comp. Strength, psi |
|------------|----------------|---------|----|---------------------|
| 5,530      | 9.0770         | 6.15    | 0.6| 0.69101             |
| 5,540      | 40.2501        | 1.70    | 0.1| 0.19101             |
| 5,550      | 38.3915        | 2.10    | 0.2| 0.23596             |
| 5,560      | 28.4039        | 2.85    | 0.3| 0.32022             |
| 5,570      | 38.4972        | 2.10    | 0.2| 0.23596             |
| 5,530      | 39.8410        | 2.00    | 0.2| 0.22472             |
| 5,580      | 51.0527        | 1.10    | 0.1| 0.12360             |

Based on the calculation of bond index and compressive strength, most of the CBL amplitude shows a good value which is below20 mV, but the hydraulic seal has not been formed because most of the bond index is below 0.8. Logging in the last formation which is a prospect zone in the F-3 well is shown in Figure 4.

Figure 4. CBL and VDL Logging on F-3, UK-C2B formation

Table 2. Analysis of Bond Index and Compressive Strength on F-3 well, UK-5 formations

| Depth (ft) | Amplitude (mV) | Att. dB | BI | Comp. Strength, psi |
|------------|----------------|---------|----|---------------------|
| 5,750      | 3.7142         | 8.55    | 0.9| 1424                |
| 5,760      | 16.4191        | 4.40    | 0.4| 180                 |
| 5,770      | 16.8661        | 4.40    | 0.4| 180                 |
| 5,780      | 27.8026        | 3.00    | 0.3| 57                  |
| 5,790      | 22.4365        | 3.55    | 0.3| 65                  |

The next well that will be discussed is F-4. This well has 2 formations as the main target, namely UK-5 and UK-C2B. The results of logging in the UK-5 formation at F-4 well can be seen in Figure 5.

Figure 5. CBL and VDL Logging on F-3, UK-5 formation

Through the calculation of bond index and compressive strength, it can be seen that the bond between cement has good quality in this formation but the hydraulic seal has not yet formed because the bond index does not reach 0.8 along 3 meters. However, the quality of cement can be said to be good with a good bond index and compressive strength. So no need to worry about leakage through this formation or the flow of water from the back of the casing due to poor cementing.

Figure 3. CBL and VDL Logging on F-3, UK-5 formation
Based on the log in Figure 5, cement has a good quality or strong bond, but cement does not have a good bond on the formation or on the casing. This is indicated from the reading of the amplitude on the CBL which shows a small to moderate value with a straight casing signal and a wavy formation signal on the VDL. One possibility is the occurrence of partial cement or incomplete cementing on the surface of the casing and formation (Yalcin, n.d.). Analysis of bond index and compressive strength in this formation can be seen in Table 4.

![Figure 5. CBL and VDL Logging on F-4, UK-5 Formation](image)

Amplitude has a very good value in the UK-C2B formation, but the same thing with the UK-5 formation occurs, namely a good bond is only a bond between cement but the bond of cement to the formation is not so good. Table 5 shows the results of bond index analysis and compressive strength in the UK-C2B formation.

![Figure 6. CBL and VDL Logging on F-4, UK-C2B Formation](image)

When viewed from bond index analysis and compressive strength, both have good values. So it can be interpreted cementing has a strong bond between cement, but the cementing is not attached to the formation or the casing is marked by a strong casing and formation signal on the VDL. Figure 6 is an analysis of the UK-C2B formation in F-4 wells.

### Table 3. Analysis of Bond Index and Compressive Strength on F-3 well, UK-C2B formations

| Depth (ft) | Amplitude (mV) | Att. (dB) | BI | Comp. Strength, psi |
|-----------|----------------|----------|----|---------------------|
| 6,040     | 9.4107         | 6.15     | 0.6| 510                 |
| 6,050     | 6.2090         | 7        | 0.7| 750                 |
| 6,060     | 3.5949         | 8.55     | 0.9| 1424                |
| 6,070     | 10.0052        | 5.85     | 0.6| 450                 |
| 6,080     | 11.7866        | 5.6      | 0.6| 405                 |

### Table 4. Analysis of Bond Index and Compressive Strength on F-4 well, UK-5 formations

| Depth (ft) | Amplitude (mV) | Att. (dB) | BI | Comp. Strength, psi |
|-----------|----------------|----------|----|---------------------|
| 5,140     | 4.9011         | 7.9      | 0.91| 1010                |
| 5,150     | 5.2117         | 7.7      | 0.89| 998                 |
| 5,160     | 9.8275         | 5.9      | 0.68| 453                 |
| 5,170     | 8.6622         | 6.3      | 0.73| 557                 |
| 5,180     | 7.9434         | 6.6      | 0.76| 655                 |
| 5,190     | 4.7446         | 8.1      | 0.94| 1152                |

### Table 5. Analysis of Bond Index and Compressive Strength on F-4 well, UK-C2B formations

| Depth (ft) | Amplitude (mV) | Att. (dB) | BI | Comp. Strength, psi |
|-----------|----------------|----------|----|---------------------|
| 5,400     | 3.5            | 9        | 0.97| 1664                |
| 5,402     | 3.8            | 8.7      | 0.94| 1495                |
| 5,404     | 4              | 8.4      | 0.91| 1295                |
| 5,406     | 3.9            | 8.55     | 0.92| 1424                |
| 5,408     | 4              | 8.4      | 0.91| 1295                |
| 5,400     | 3.5            | 9        | 0.97| 1664                |

Analysis of the bond index and compressive strength above supports that cementing has a good bond between cement, which is indicated by a small amplitude, so the value of compressive strength is high. However, with the distance between the casing and cement or formation and cement it is feared that it can become a pathway for fluid flow, in this case it is feared that water will be produced. Hydraulic seal has been formed in
cementing this formation marked by a bond index value that reaches 0.8 along 3 meters.

In addition, an analysis of spacer pumping was carried out with the same volume in each well, namely 30 bbl. Table 6 shows a comparison of the contact time spacers in the F-3 and F-4 wells.

Table 6. Spacer Comparison between F-3 Well and F-4 Well

| Well   | Rate Spacer (bpm) | Vol. Spacer (bbl) | Contact Time (min) |
|--------|-------------------|-------------------|-------------------|
| F-3    | 5.0               | 30                | 5                 |
| F-4    | 4.5               | 30                | 5                 |

Based on the table above, it can be seen that the contact time in the two wells observed is not sufficient for the recommended minimum contact time of 10 minutes. To achieve a contact time of 10 minutes there will be a change in the volume of the spacers. The following is the calculation to get a contact time of 10 minutes.

\[
\text{Vol.Spacer} = \text{Contact Time} \times \text{Dis. Rate} \quad (2)
\]

With the above calculations, the results of the contact time and volume spacer will be obtained as shown in the Table 7.

Table 7. Spacer Comparison between F-3 Well and F-4 Well with Contact Time 10 min

| Parameter       | F-3 | F-4 |
|-----------------|-----|-----|
| Volume (bbl)    | 5.0 | 30  |
| Contact Time (min) | 4.5 | 30  |

The volume of spacers will increase with the increase of contact time. That way it is hoped that better displacement will occur.

IV. CONCLUSIONS

Based on the analysis that has been done on F-3 and F-4 wells, both have good cement bond quality, there are only a few depths which are estimated to be not completely attached to the cement formation or the cemented casing as a whole.

High water production is estimated due to the absence of hydraulic seals that are marked with a bond index of 0.8 along 3 meters (hydraulic seals are only formed in the F-4 well formation UK-C2B), so there may be water flowing from behind the casing from other formations which has been filled with water into the production formation so that the water is also produced.

Besides that, the slurry volume also needs to be considered in order to get a good isolation zone on cementing.

To overcome this problem, secondary cementing or remedial cementing needs to be done to cover cementing with low quality so that water cannot flow from one formation to another. In addition, further analysis to overcome the high water production can be done because the high water produced can be due to mechanical problems or the production of water coming from the aquifer reservoir.

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Figure 1. Research Procedure