

## **Evaluation of Water Channeling Problems and Planning for Its Improvement Using the Remedial Cementing Method and Its Economics in Well AB-30 Field AB PT. Pertamina EP**

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### **ABSTRACT**

The AB-30 well is an oil producing well located in the AB Field. Production performance data shows that AB-30 shows excessive water production behavior or is a high water cut production well. In addition, the interpretation of CBL data shows an amplitude value of <10 mV in the productive interval. This condition is an indicator that the primary cementing activity in this well is not good. Therefore, a comprehensive and integrated analytical method is needed to identify the problem of excess water production and to design and plan water shut-off activities through squeeze cementing as an effort to mitigate the problem of high water cut to economic analysis.

The research begins by identifying the problem of excess water production, whether caused by water channeling, water coning, changes in water oil contact, or by the physical properties of the reservoir rock. Identification is done through production analysis and water diagnostic plots. The next stage is to evaluate the interpretation of CBL Logging results to strengthen the results of production data analysis. After confirming that the problem of excess water production is caused by poor cement bonding cement, the next step is to calculate the cement work program in order to repair the bad cement bonding. Subsequently, the productive zone interval re-perforation was carried out according to the results of the OH Loh Co Log evaluation. No less important is to conduct an economic analysis as a basis for whether or not this work is feasible.

The result of this research is that the water shut-off activity went well and was able to reduce the level of excess water production in the AB-30 well and optimize oil production so as to provide a good economic indicator of oil recovery. Remedial cementing work for bonding repair was carried out at well AB-30. The first work is to close the existing layer, followed by Logging evaluation (CBL-USIT). The evaluation results showed that the cement bonding was good with the CBL amplitude parameter < 10 mV. After that, the productive zone reperforation was carried out. The economy by considering the values of economic indicators such as Pay Out Time and Rate Of Investment showed positive results so that the priority and strategy of well intervention could be continued. The results obtained before the well intervention were 148 BOPD oil production, 97% water cut after well intervention was 880 BOPD average oil production, 0% water cut for 1.5 months

**Keywords:** Water Cut, Remedial cementing, Poor Bonding Cement, Chan Plot

### **I. INTRODUCTION**

AB Field has been operated by PEP Asset 4 since May 2018 where previously it was operated by JOB Pertamina – Petrochina East Java (JOB PPEJ). AB field began to be produced in 2004 with a total amount of water produced  $\pm 30,000$  BOPD. Field AB has 2 well locations, namely pad A and pad B. The structure of Field AB is included in the East Java basin which was discovered in 2001. SSOP data reference dated August 14-19 2019 recorded oil in place (OOIP): 297 MMSTB, cumulative production until 2018/CUMM 2018: 118.8 MMSTB and 34.35 MMSTB remaining reserves that have not been taken, with a recovery factor of 50% from oil in place. Based on the value of the remaining reserves that have not been taken, the best recommendations are needed in optimizing production and applying the right operating pattern in accordance with existing field conditions to be able to deplete the remaining reserves as much as possible.

It is known that wells in Field AB have high water content and in general are fields with high levels of water production, so it is necessary to handle production wells that have problems with high water content, one of which is well AB-30. High water cut production can also occur when the WOC is near the bottom existing perforation. Water channeling can occur due to fracture channeling, multi-layer channeling, and poor cement bonding.

The AB-30 well is an oil producing well located in the AB Field. Production performance data shows that the well shows excessive water production behavior or is a high water cut production well. From these data, it is necessary to

compare the well integrity log data of the well to ensure indicators that the primary cementing activity in this well is not good enough to form poor bonding cement.

Therefore, a comprehensive and integrated analytical method is needed to identify the problem of excess water production, evaluate cement bonding, design and plan remedial cementing activities, and evaluate cement bonding after remedial cementing activities and their impact on efforts to mitigate high water problems. cut to the economic analysis in order to improve the production performance of the AB Field.

## II. METHODS

The methodology in this study begins with an assessment of the data on the well in the form of performance CBL production and yield

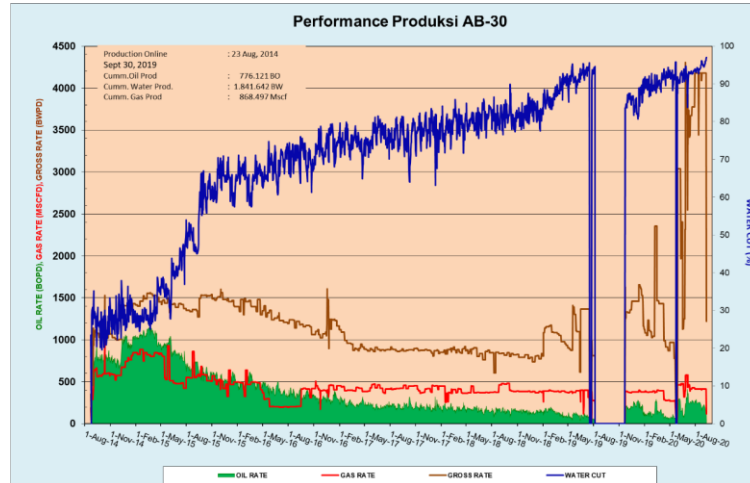
In detail the steps in the study were carried out as follows:

1. Analyze production performance using the chan diagnostic plot to determine the cause increase in water level.
2. Evaluate log interpretation (CBL) to ascertain the cause of the increase in water content.
3. Perform a cementing strategy to repair the bonding behind the casing.
4. Calculating the days and operating costs of repair work.
5. Calculate the economy of the well if repairs are carried out as a basis for the feasibility of the well to be carried out repair or not..

## III. RESULTS AND DISCUSSION

### 3.1 AB-30 Well Production Performance Analysis

The AB field is located in Bojonegoro, East Java with an oil reservoir, the Tuban formation, with carbonate rock types. The wells in Field AB which were analyzed in this study experienced problems with producing water, one of which was well AB-30..



**Figure 3.1**

### Production Performance of Well AB-30 (Pertamina EP, 2020)

Figure 3.1. It can be seen that in 2014 AB-30 was produced starting in 2014. Judging from the trend, the AB-30 water cut tends to increase and is followed by a significant decrease in oil production. From August 2019 to November 2019, workover work was carried out to reduce water cut and increase oil production. However, the results obtained are that the increase in oil production is not too significant and water production is still high at around 4000 BWP/D. From this, it is necessary to analyze the problem of water in the well so that oil reserves can be produced optimally.

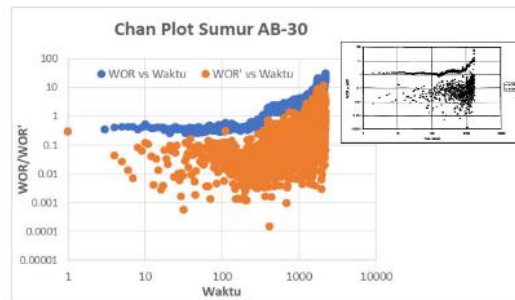
**Tabel 5.1.**  
*Average tahunan Produksi AB-30*

Year	FWHP (psig)	TIME HOURS PROD.	BOPD	BWPD	BFPD	MSCFD	Wcut (%)	G-OR (scf/bbl)
2014	839.79	23.60	776.32	293.31	1069.63	584.57	27.33	757.78
2015	697.00	23.98	808.05	644.32	1452.37	643.28	44.24	811.93
2016	463.30	23.92	405.76	867.88	1273.64	362.71	68.41	917.46
2017	407.35	23.87	224.84	702.46	927.29	418.39	75.83	1920.74
2018	386.36	24.00	164.98	673.06	838.05	396.61	80.37	2483.78
2019	206.93	16.30	88.83	671.16	759.98	257.24	88.22	3339.01
2020	250.55	16.91	148.94	1355.30	1504.23	302.09	90.44	2605.62

From Table 5.1, the largest production was in 2015, where the AB-30 well produced an average of 808 BOPD with 44% WC. In 2020, the increase in water production will be higher followed by a decrease in production to an average of 148 BOPD. How to analyze production problems, one way is from Chan's Diagnostic Plot analysis, namely the plot between WOR and WOR' against time.

### 3.2 Evaluation of Production Problems (Chans Diagnostic Plot)

The way to find out the water problem is diagnosed with Chan's Diagnostic Plot, namely by plotting between WOR and WOR' with time and identifying whether the type of water problem experienced is in the form of water coning or water channeling. Figure 5.3 shows an analysis plot of water problems at Well AB-30.

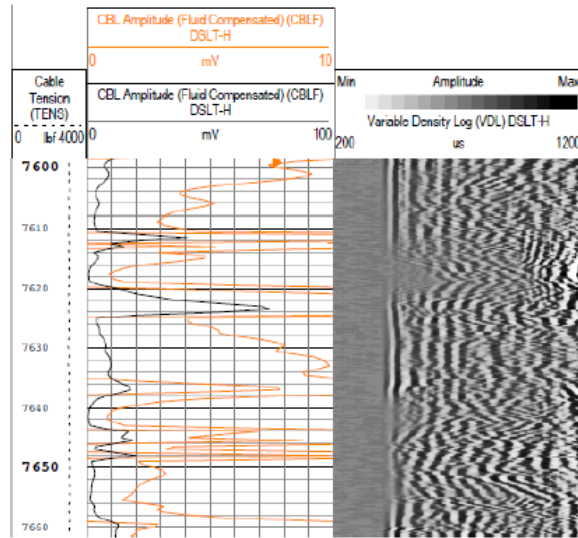


**Gambar 5.2.**  
 Analisa Diagnostic Chan Sumur AB-30

Analysis of Diagnostic Chans Well AB-30 obtained the results of the analysis in the form of Near Wellbore Water Channeling. This type of channeling occurs where there is a water zone near the wellbore/perforation interval so that water penetrates through the gaps between the formation and the casing, the results from Chan's Diagnostic Plot prove that water channeling occurs because the cement between the casing and the formation is not completely insulated due to carbonate rock formations. , this carbonate formation has a very high level of reservoir heterogeneity in the form of cavities or vuggy which causes total loss during drilling operations or well maintenance operations..

### 3.3 CBL Result Evaluation (Cement Bond Log)

The results of this channel analysis are then supported by Cement Bond Log (CBL) data. Cement Bond Log (CBL) is a tool to see or interpret the condition of the cement bond between the casing and the formation shown in mVolt units. The lower the CBL value, the better the bond between the casing and the formation and vice versa. The following is the Cement Bod Log (CBL) of Well AB-30 in Figure 5.3.



**Gambar 5.3.**  
*Cement Bond Log (CBL) AB-30 (Pertamina EP, 2019)*

From the analysis data on the problem of produced water based on Chan's Diagnostic Plot and from the CBL data it shows that in the wells in Field AB there is water channeling behind casing. After knowing the problem, a cementing job will be carried out to repair the bonding behind the casing.

### 3.4 Cementing Job Strategy

Cement job strategy to cover 7629 - 7640 ftMD intervals with Squeeze Job. can use equation below :

It is known from the results of the AB-30 Injectivity Rate test:

Rate (Q) : 3 bpm Press (P) : 426 psi

then the estimated volume of cement that needs to be squeezed can be calculated as follows:

$$\begin{aligned}
 Vol\ Squeeze &= \frac{11,000 \times rate\ (bpm)}{Pressure\ (psi)} \times Yield\ \left(\frac{cuft}{sax}\right) \\
 &= \frac{11,000 \times 3}{426} \times 1.56 = 120.85\ bbl
 \end{aligned}$$

Based on the results above, the condition of the well is stated, the calculation method used is the balanced plug method. The stages for cementing work are as follows:

1. Pump 5 bbl fresh water as water ahead

$$V_s = \{ (intv\ perfo\ (ft) \times SPF \times Vol/Shoot) + Vol\ borehole \}$$

$$V_s = (11\ ft \times 5 \times 0.000757\ bbl/shoot) + 2.26\ bbl$$

$$V_s = 2.3\ bbl$$

$$V_c = \{ h \times (C_t + C_a) \} + V_s$$

2. Cement slurry pump, to determine the amount of cement slurry:

$$\text{Cap Ann} = \frac{ID_{\text{csg}}^2 - OD_{\text{dp}}^2}{1029.4} = \frac{6.276^2 - 3.5^2}{1029.4} = 0.0263 \text{ bbl/ft}$$

Volume semen yang akan diletakkan didalam casing sepanjang 400 ft dari top perforasi,

$$V_c = \{(400) \text{ ft} \times (0.0074 \text{ bbl/ft} + 0.0263 \text{ bbl/ft}) + 2.3 \text{ bbl}\} \\ = 15.8 \text{ bbl}$$

3. Pump fresh water as water behind

$$Vol_{wb} = \frac{Vol_{wa} \text{ (bbl)} \times Ct}{Ca} = \frac{5 \times 0.0074}{0.0263} = 1.5 \text{ bbl}$$

4. Displace pump with CF

$$h_{\text{slurry}} = \frac{V_{\text{slurry}}}{Ct+Ca} = \frac{15.8}{0.0074+0.0263} = 468.13 \text{ ft}$$

$$h_{\text{spacer}} = \frac{V_{\text{spacer}}}{Ct+Ca} = \frac{1.4}{0.0074+0.0263} = 41.56 \text{ ft}$$

$$V_d = \{OE - (h_{\text{slurry}} + h_{\text{spacer}})\} \times Ct \\ = \{7447 \text{ ft} - (468.13 \text{ ft} + 41.56 \text{ ft})\} \times 0.007 \text{ bbl/ft} = 51.34 \text{ bbl}$$

5. POOH the OE to a safe position from cement contamination,

$$\text{Raise Up (ft)} = h_{\text{slurry}} \text{ (ft)} + h_{\text{spacer}} \text{ (ft)} + h_{\text{safety}} \text{ (ft)} \\ = 468.13 \text{ ft} + 43.56 \text{ ft} + 300 \text{ ft} = 809 \text{ ft}$$

Atau equivalen 26 jts di cabut.

6. Reverse circulation to clean the Open End circuit from cement contamination with 2 x bottom ups (vol. Open End circuit)

$$Vol_{\text{reverse}} = 2 \times ((7,447 \text{ ft} - 809 \text{ ft}) \times 0.0074 \text{ bbl/ft}) = 98 \text{ bbl}$$

7. Close the BOP, clean the remaining cement contamination in the string with reverse circulation, until the cement contamination comes out or 2 x volume bottom up.
8. Squeeze cement and wait for cement to harden.

### 3.5 Operational Cost Calculation

From the day of operation, the estimated cost to be invested is USD 348,349. The details of the costs that will arise from the work of the AB-30 well are as follows:

Description	Qty	Cost/Day	Cost/Job	Cumm Cost (USD)	Cumm Cost (IDR)
R/M, R/U, R/D (Lumpsum)	1		\$ 8,618.75	\$ 8,618.75	\$ 124,971,875.00
Operasi	18.5	\$ 8,800.00		\$ 162,800.00	\$ 2,360,600,000.00
Cementing Job :	1		\$15,131.37	\$ 15,131.37	\$ 219,404,928.45
Wireline Logging	1		\$25,779.40	\$ 25,779.40	\$ 373,801,294.11
Perforasi	1	\$22,728.12		\$ 22,728.12	\$ 329,557,803.44
Completion Eng	1	\$ 2,102.22		\$ 2,102.22	\$ 30,482,222.22
H2S SERVICES	1	\$ 462.88		\$ 462.88	\$ 6,711,788.19
Basic Slickline Equipment	5	\$ 1,145.83		\$ 5,729.17	\$ 83,072,916.67
Downhole Material	1		\$59,876.32	\$ 59,876.32	\$ 868,206,706.46
COMPANY MAN PERTAMIN	1	\$ 102.00		\$ 102.00	\$ 1,479,000.00
HSE SUPERVISOR	1	\$ 150.00		\$ 150.00	\$ 2,175,000.00
Solar	1	\$ 1,137.94		\$ 1,137.94	\$ 16,500,093.75
XCD (Mud Chemical)	1		\$ 290.21	\$ 290.21	\$ 4,208,020.83
Tubing	1		\$33,191.81	\$ 33,191.81	\$ 481,281,195.66
NaCl (Mud (Chemical))	1		\$ 9,112.50	\$ 9,112.50	\$ 132,131,250.00
Cement Class G	1		\$ 1,136.31	\$ 1,136.31	\$ 16,476,561.96
Bit All Size				\$ -	\$ -
<b>TOTAL COST</b>				\$ 348,349.01	\$ 5,051,060,656.74

### 3.6 Economic Calculation Analysis

Apart from the technical aspect, economic analysis needs to be done as a basis for evaluating the success of a project. In this calculation, ignore the calculation of the system cost recovery or gross split and ignore the state revenue sharing in the form of taxes.

From the data that has been obtained both from the potential of the well and from operating costs for the purposes of calculating economic sensitivity, it can be resumed as follows::

Biaya Sumur (reff Table 5.9)	\$348,349
Biaya OPEX Sukowati	\$10.60
Qoi Gain Produksi	300 Bopd
Decline Rate	30%
Asumsi Umur Sumur	12 Bulan
Asumsi Harga Minyak	40 bbl

#### 1. Pay Out Time (POT) Sumur AB-30

Dengan menggunakan persamaan (4-12) maka dapat dihitung angka *Pay Out Time* sebagai berikut :

$$\begin{aligned}
 POT \text{ (Months)} &= \frac{(US \times BS)}{P \text{ (bbl)} \times OP \times \text{Decline Rate}} \\
 &= \frac{(12 \times 348,349)}{(300 \times (40) \times (100\% - (30\%/2) \times 365))} = 1.5 \text{ Bulan}
 \end{aligned}$$

The POT for well AB-30 is 1.5 months. Then with the same calculation method and assuming fluctuating oil prices, the POT sensitivity table will be obtained as follows::

POT (Bulan)		Gain (bopd)					
		100	150	200	250	300	350
ICP (USD/bbl)	20	14.5	9.7	7.3	5.8	4.8	4.2
	30	7.0	4.7	3.5	2.8	2.3	2.0
	40	4.6	3.1	2.3	1.9	1.5	1.3
	50	3.5	2.3	1.7	1.4	1.2	1.0
	60	2.8	1.8	1.4	1.1	0.9	0.8

Based on the table above, well AB-30 is considered economical with POT for 1.5 months. Well AB-30 will be reconsidered / not economical if the table touches the yellow color. And or the oil gain is less than 100 bopd with oil price of 20 USD/bbl.

## 2. Rate Of Investment (ROI) Sumur AB-30

Lalu dengan menggunakan persamaan (4-13) maka dapat dihitung persentasi *Return Of Investment* sebagai berikut :

$$\begin{aligned}
 ROI (\%) &= \frac{(P \times OP \times \text{Decline Rate}) - BS}{BS} \times 100\% \\
 &= \frac{((300 \times (40) \times (100\% - (30\%/2)) \times 365) - 348,349)}{348,349} \times 100\% \\
 &= 675\%
 \end{aligned}$$

The ROI calculation of the AB-30 workover well of 675% indicates that this investment has a very good profit ratio. Then with the same calculation method and assuming fluctuating oil prices, the ROI sensitivity table will be obtained as follows :

ROI (%)		Gain (bopd)					
		100	150	200	250	300	350
ICP (USD/bbl)	20	-17%	24%	65%	106%	148%	189%
	30	70%	156%	241%	326%	411%	496%
	40	158%	287%	417%	546%	675%	804%
	50	246%	419%	592%	765%	938%	1111%
	60	334%	551%	768%	985%	1202%	1419%

Based on the above, . well AB-30 is considered economical with an ROI of 675%. Well AB-30 will be reconsidered / uneconomical if the table touches the color yellow. And or the oil gain obtained is less than 150 bopd with an oil price of 30 USD/bbl

## Discussion

The AB field is an oil and gas field that produces carbonate rock in the tuban formation. The AB field was produced from 2004 to the present (in 2020). The characteristics of the reservoir in the carbonate rock of the tuban formation are that it has a fairly high heterogeneity such as varying permeability and porosity. During the drilling process, circulation loss often occurs which causes the results of primary cementing in wells in Field AB to be not good and there is a problem of excessive water being produced so that oil reserves are not optimally drained in wells in field AB, one of which is well AB-30. Based on the data from the sub surface (table 5.2) and assuming the Np Limit is 50% x OOIP, the ERR (Estimated Oil Reserve) value of well AB-30 that can still be optimized is 0.142 MMBL.

Identification of production problems in well AB-30 using diagnostic chans plot analysis, namely the plot between WOR and WOR' against time. Analysis of Diagnostic Chans Well AB-30 obtained the results of the analysis in the form of Near Wellbore Water Channeling. This type of channeling occurs where there is a water zone near the wellbore/perforation interval so that water penetrates through the gaps between the formation and the casing. The results of the well integrity evaluation in the form of interpretation of CBL readings > 10mV strengthen the assumption of channeling in the produced zone.

Based on the results of the evaluation of production performance and interpretation of logs (CBL), the proposed improvement of the zone that occurs in channeling is done by remedial cementing. From the results of calculations carried out based on the results of the injectivity rate of the well, the cementing strategy is obtained :

**Table 6.1**  
**Strategi Penyemenan**

No	Deskripsi	Qty	Unit
1	Pompa Water Ahead	5	bbl
2	Pompa Slurry cement 15.8 ppg	15.8	bbl
3	Pompa Water Behind	1.5	bbl
4	Pompa Displace	51	bbl
5	Cabut rangkaian OE	26	jts
6	Sirkulasi reverse	98	bbl
7	Tutup BOP		
8	Lakukan Squeeze cement	3	bbl
9	Tunggu semen hingga keras.	12	Jam

Repair of cement bonding requires a fairly long series of works, the following are proposed improvement strategies:

- Rig Move, Rig Up in well AB-30
- Killing Well or perform procedures to secure the well before the completion circuit is pulled to the surface.
- N/U Xmastree well and install BOP (Blow Out Preventer)
- POOH to the surface of well completion circuits, such as Packer, SSD, TRSCSSV, XN-Nipple.
- RIH OE of cementing Squeezed cementing
- Squeezed cementing program
- POOH the Squeezed cementing OE of cementing.
- RIH and POOH scrapper
- Job Logging Job
- Production zone perforation
- RIH a series of completions such as Packer, SSD, TR-SCSSV, XN Nipple.
- Unload BOP, Install X-mastree
- Produce Wells

The estimated cost to be invested is USD 348,349.

The calculation of economic indicators to produce the economic value of well AB-30 is:

1. Pay Out Time (POT): 1.5 months, which means that the investment costs that have been spent will return for 1.5 months if the well produces at least 300 BOPD with an oil price of USD 40 /bbl.
2. Rate Of Investment (ROI): 572%, which means the percentage of profit that can be obtained from the total investment assets is 572% if the well produces at least 300 BOPD for 1 year with an oil price of USD 40 /bbl.

#### IV. CONCLUSION

Based on the analysis of reservoir and production data processing, prediction of production problems and economic analysis in this study, it can be concluded as follows:

1. Well AB-30 Chan's plot analysis shows that this well is experiencing nearbore channeling.
2. CBL data which shows the interpretation of amplitude > 10 mV, this indicates the presence of poor bonding cement on the INTV.
3. Closure of 7,629 ftMD – 7,640 ftMD (11 ft), with the cement plug method, the required volume of cement slurry is 15.8 bbl.
4. Opening the production layer at intervals of 7629 – 7640 ftMD with an operating time of 18.5 days and a cost of \$348,349.
5. Economic analysis of well AB-30 with the assumption that the lifetime of the well is 12 months, decline is 30%/year, oil price is \$40/bbl and operating cost (OPEX) is \$10.6/bbl, then the POT figure is 1.5 months and the ROI figure is 675 % so that the well is still feasible to work on.



- The well in AB-30 has carried out a Well intervention in accordance with the proposed priority of well intervention work and economic calculations, so that a fairly good production gain of 880 BOPD and 0% Water Cut is obtained.

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