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EVALUATION OF LOSS CIRCULATION TREATMENT IN WELL Z-5, Z-10, Z-12 AND Z-13 AT L FIELD

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Abstract

Loss circulation is a problem of partial or complete loss of the drilling fluid into the formation, causing fluid circulation becomes impaired. This final assignment will discuss about the loss of circulation in field L. There are 4 development wells in field L, which is Z-5, Z-10, Z-12, and Z-13. Some loss circulations in some depths are caused by natural factors. Some depths during loss circulation being evaluated are in Cisubuh and Parigi formations with limestone rock and claystone rock lithology, which have a large pore size in the drilling mud to enter and loss into the formation.

Treatment loss circulation in this field is blocking with loss circulation material with various compositions. However, some depths after the LCM blockage has not been successfully handled, so the cementing plug process is performed to overcome the loss circulation. The treatment that carried out in the loss zones have been successfully stopped the loss circulation, so that the drilling process can be continued to reach the desired final depth of the well.

Keywords: Loss Circulation, Natural Fracture, Treatment, Lithology, Loss Circulation Material, Cementing Plug

Introduction

Field L is part of the Northwest Java Basin which was formed due to the rifting phase in the Eocene period and is also the edge of the Sundaland continent. The Northwest Java Basin consists of 4 depocenters, namely the North, Central, South Arjuna sub-basins, and the Jatibarang sub-basins. The depocenter is filled predominantly by Tertiary sediment deposits with a thickness of more than 5500 meters.

Field L is located in the Talang Akar and Baturaja formations. The Talang Akar Formation contains quartz sandstone, shale, coal and there is a small amount of limestone which is located alternately. Meanwhile, the Baturaja formation contains carbonate rocks and is used as a significant seismic marker for the L field. For the depositional environment, this formation comes from a deltaic environment and there are also fluvial deposits.

Based on the Tertiary stratigraphy region, there are 6 formations in the Northwest Java Basin, namely Banuwati/Jatibarang, Talang Akar, Baturaja, Main-Massive, PreParigi-Parigi, and Cisubuh. For the Talang Akar, Baturaja, Main-Massive, and Parigi formations, they act as effective traps for hydrocarbon accumulation.

Loss circulation is most or all of the drilling fluid into the formation so that the fluid circulation is not perfect. In general, the loss of circulation occurs because the hydrostatic pressure of the mud is greater than the formation pressure so that the mud enters the formation.

In this study, we will discuss how the circulation loss occurs, as well as take effective countermeasures so that drilling can be resumed. Well Z in L is a development well located in the west of the Java Sea, close to the Thousand Islands. These wells will penetrate the Cisubuh, Parigi, Baturaja, Talang Root, Jatibarang and Basement formations. In wells Z-5 and Z-10 there is a loss circulation on the 17-1/2” route, while in wells Z-12 and Z-13 there is a loss circulation on the 12-1/4” route with the types of loss namely total loss and partial loss so that Circulation loss is handled by lowering pump pressure, reducing material loss circulation, and cementing plugs.

Loss circulation is the loss of a number of drilling fluids that enter the formation, caused by the presence of open spaces in the formation that exceed the diameter of the mud particles or caused by the borehole pressure is too high that exceeds the formation fracturing pressure.

Open space formations which are natural conditions are usually found in permeable sand formations with coarse grains and are not well consolidated. Caves or open cavities are found in compact formations, while natural fractures can be found in every rock layer. This type of fractured rock is often found in geothermal areas.

Sometimes the loss of circulation is also caused by the drilling operation itself. This is caused by the borehole pressure that is too high due to the pressure of the mud column in the borehole and the addition of pressure from the mechanical pressure that occurs during the drilling operation, thus exceeding the fracture pressure. Loss of circulation is a serious and expensive problem to treat. This problem occurs in the drilling area, depth, rock type and geological age of the rock.

Loss circulation can be caused by the type of formation, namely because of the type of porosity and large permeability and the presence of caves and formation fractures.

In terms of formation, mud loss can occur in Coarsely permeable formations (formations with permeable coarse grains), Cavernous formations (open caves), fissures, fractures, faults.

The occurrence of lost mud circulation can be classified according to the amount or volume of mud lost into 3 types, namely Seepage losses, Partial losses and Total losses.

Seepage is when the mud is lost in relatively small amounts, ranging from 1-10 bbl/hour, it can occur in every type of formation consisting of porous sand and gravel, natural fractures and in formations with fractures (limestone) and induced fracture (fracturing is not natural).

Partial is the occurrence of mud that is only partially lost and there is still mud flowing to the surface. The mud that has the potential to be lost to the formation will range from 10-500 bbl/hour. Generally it can occur in formations consisting of porous sand and gravel, and occasionally occurs in rocks containing fractures (natural fractures and fractures induced).

Complete is the total loss of mud or no return of mud to the surface. There will be a decrease in hydrostatic pressure, which can cause a well kick.

This problem has the potential to occur in formations that contain caves as well as very large fractures and formations with subnormal pressure.
Loss circulation can cause several problems and losses, for example: Loss of mud, danger of pipe jamming, formation damage, lost time, not getting cuttings for sample logs, subsidence of mud surface can cause blowout in the next formation.

To avoid problems that arise due to loss circulation, it must be prevented or overcome when it occurs. Some methods that can be used to overcome circulation loss are:

- Reducing Pump Pressure
- Reducing Sludge Weight
- Increases Viscosity and Gel Strength
- Reducing Borehole Surge Pressure
- Loss Circulating Material (LCM)
    - Fibrous Material
    - Material Flakes
    - Granular Material
- Cement
- Blind Drilling

Data and Method

The purpose of this research is to evaluate whether the cause of loss circulation is caused by natural factors or caused by mechanical factors such as hydrostatic pressure, the value of Equivalent Circulating Density, Bottom Hole Circulating Pressure, and Pressure Surge. Thus, from this analysis, it is possible to determine what methods are appropriate to overcome problems in loss circulation in the L field.

Leak Off Test is performed to determine the pressure at which the formation begins to fracture. The goal is to determine the maximum surface pressure and maximum mud weight.

The calculation of equivalent circulating density and bottom hole circulating pressure is carried out to determine whether ECD and BHCP pass the formation fracture pressure or not.

Calculation of pressure surge is carried out to determine whether this surge pressure exceeds the fracture pressure or does not exceed the fracture pressure. Here is the result of the calculation.

Result and Discussion

Loss circulation problems in this field occur in wells Z-5, Z-10, Z-12 and Z-13 and are found in various formations in the field. Loss circulation in this field can be caused by various obstacles, some of which occur due to the type of formation that has coarse-grained rocks and can also occur due to pressure factors. The rock lithology in these wells is dominated by limestone so that there are natural fractures and has a low formation pressure gradient. It is important to evaluate the physical properties of the drilling mud and the use of loss circulation material used in drilling this well. In the wells in field L there is a loss of circulation and the types of losses are partial loss and total loss, and the amount is different. In Table 4.1 the following is a table of data on the number of losses, types of losses and formations contained in Field L:

Table 4.1
Loss Circulation on Field L

Well	Traject	Depth	Formation	loss	MW
	inch	Ft TVD		bph	ppg
Z-5	17-1/2	928	Cisubuh	400	9
Z-5	17-1/2	1104	Cisubuh	Total	9
Z-10	17-1/2	409	Cisubuh	200	9
Z-10	17-1/2	800	Cisubuh	300	9,2
Z-12	12-1/4	1998	Parigi	60	9,2
Z-12	12-1/4	2325	Parigi	60	9,3
Z-13	12-1/4	2531,5	Parigi	Total	9,3
Z-13	12-1/4	2614,4	Parigi	79	9,2

Loss circulation will hinder the drilling operation so that an analysis is carried out to determine the cause of the lost circulation. Therefore, the calculations carried out are the calculation of Hydro-static Pressure (Ph), Formation Pressure (Pf), Formation Fracture Pressure (Pfr), Equivalent Circulating Density (ECD), Bottom Hole Circulating Pressure (BHCP), and Pressure Surge (Psurge). Calculation of formation fracture pressure using equation (3.16).

Meanwhile, to calculate the hydrostatic pressure of the mud at the time of loss using equation (3.14), and to calculate the formation pressure can use equation (3.13).

Table 4.2 below shows the results of the calculation of formation fracture pressure, hydrostatic pressure and formation pressure in Field L:

Table 4.2
Result Pressure in Field L

Well	Depth	Pfr	ρmax	Phyd when loss	Pf
	Ft TVD	psia	ppg	psia	psia
Z-5	928	532,30	11,03	434,3	334,46
Z-5	1104	614,67	10,71	516,67	370,01
Z-10	409	241,41	11,35	191,41	157,62
Z-10	800	582,72	14,01	382,72	474,08
Z-12	1998	1160,84	11,17	955,84	742,26
Z-12	2325	1329,37	11	1124,37	831,55
Z-13	2531,5	1446,23	10,99	1224,23	903,60
Z-13	2614,4	1472,73	10,83	1250,73	901,89

The bottom hole assembly used in the 928 ft TVD depth is 17-1/2" BHA. The calculations carried out are the calculation of the velocity of the mud flow in the annulus using equation (3-8) and the critical flow velocity in the annulus with equation (3-9), as well as calculating the pressure loss with equation (3-10).

In Table 4.3 below are the results of the calculation of flow velocity and critical velocity at a depth of 928 ft TVD in well Z-5:

Table 4.3
Annual Velocity and Critical Velocity on 928 ft TVD

BHA	Va	Vc	Ploss
	ft/min	ft/min	psia
Sperry Lobe	114,70	384,17	0,27
Float Sub	101,14	366,25	0,01
NMDC	101,14	370,29	0,05
LWD	103,95	370,29	0,14
Power Pulse	103,95	361,50	0,19
NMDC	98	366,25	0,18
UBHO Sub	101,14	364,99	0,02
Over Sub	100,28	348,87	0,02
HWDP	90,66	348,87	0,86
Drilling Jar	92,80	352,84	0,16
Drill Pipe	87,11	341,54	4,26

So that the value of the velocity of the mud flow in the annulus, the critical velocity and the value of the pressure loss are obtained. So the total pressure loss at a depth of 928 ft TVD is 6.17 psia. The bottom hole assembly used at a depth of 409 ft TVD is BHA 17-1/2".

In Table 4.4 the following are the results of the calculation of flow velocity and critical velocity at a depth of 409 ft TVD in well Z-10:

Tabel 4.4
Annual Velocity and Critical Velocity on 409 ft TVD

BHA	Va	Vc	Ploss
	ft/min	ft/min	psia
Drilling Motor	52	326,29	0,06
Stabilizer	65,74	401,90	0,04
NMDC	65,74	401,90	0,12
LWD	66,86	405,57	0,11
Power Pulse	66,86	405,57	0,15
NMDC	65,74	401,90	0,13
UBHO Sub	65,74	401,90	0,01
X-Over Sub	65,74	401,90	0,02
HWDP	56,62	365,98	0,58
Drilling Jar	60,32	382,29	0,13
Drill Pipe	56,62	365,98	2,21

So, the total pressure loss at 409 ft TVD is 3.54 psia. The bottom hole assembly used in the 1998 ft TVD depth is 12-1/4" BHA.
In Table 4.5 the following are the results of the calculation of flow velocity and critical velocity at a depth of 1998 ft TVD in well Z-12:

Table 4.5
Annual Velocity and Critical Velocity on 1998 ft TVD

BHA	Va	Vc	Ploss
	ft/min	ft/min	psia
Drilling Motor	384	592,15	2,95
MWD Sub	268,90	536,37	0,12
MWD Ontrack	268,90	536,37	0,83
MWD Modular	268,90	536,37	0,27
MWD BCPM	268,90	536,37	0,51
MWD Top	268,90	536,37	0,12
NMDC	256,21	528,79	1,03
X-Over Sub	268,90	536,37	0,16

HWDP	184,04	474,35	8,46
X-Over Sub	214,50	500,42	0,08
Drilling Jar	204,52	492,55	0,74
X-Over Sub	214,50	500,42	0,09
Drill Pipe	184,04	474,35	7,85

So the total pressure loss at 1998 ft TVD is 23.20 psia. The bottom hole assembly used at a depth of 2531.5 ft TVD is BHA 12-1/4".

In Table 4.6 the following is the result of calculating the flow velocity and critical velocity at a depth of 2531.5 ft TVD in well Z-13:

Table 4.6
Annual Velocity amd Critical Velocity on 2531,5 ft TVD

BHA	Va	Vc	Ploss
	ft/min	ft/min	Psia
Drilling Motor	405,33	580,73	2,71
MWD Sub	283,84	500,21	0,10
MWD Ontrack	283,84	500,21	0,70
MWD Modular	283,84	500,21	0,23
MWD BCPM	283,84	500,21	0,43
MWD Top	283,84	500,21	0,10
NMDC	270,44	489,58	0,84
X-Over Sub	283,84	500,21	0,14
HWDP	194,26	415,56	6,29
X-Over Sub	226,42	450,49	0,06
Drilling Jar	215,88	439,85	0,59
X-Over Sub	226,42	450,49	0,07
Drill Pipe	194,26	415,56	5,91

So the total pressure loss at a depth of 1998 ft TVD is 18.17 psia.

Equivalent Circulating Density (ECD) and Bottom Hole Circulating Pressure (BHCP) which exceed the formation fracture pressure will cause the formation to fracture and cause drilling fluid to enter the formation. After calculating the total pressure loss that occurs in each drilling series in the lost circulation zone, the ECD value can be calculated using equation (3-11) and also the BHCP value (3-12).
In Table 4.7 the following are the results of the ECD and BHCP calculations for wells Z-5, Z-10, Z-12, and Z-13:

Table 4.7
ECD and BHCP in Field L

Well	Traject	Depth	ECD	BHCP
	inch	Ft TVD	ppg	Psia
Z-5	17-1/2	928	9,13	440,47
Z-5	17-1/2	1104	9,08	521,24
Z-10	17-1/2	409	9,17	194,96
Z-10	17-1/2	800	9,30	386,90
Z-12	12-1/4	1998	9,42	979,04
Z-12	12-1/4	2325	9,50	1148,05
Z-13	12-1/4	2531,5	9,44	1242,41
Z-13	12-1/4	2614,4	9,33	1268,90

Pressure Surge is the pressure that occurs when inserting the drill string into the drill hole. The nature of the mud and the procedure for inserting the tool must be controlled and observed so that the pressure surge is not too high. A pressure surge that is too high can cause the formation to fracture and drilling mud into the formation, this can also be one of the causes of loss circulation. Calculation of the pressure surge in the Z-5 well is done by determining the fluid velocity with the equation (3-7), the flow velocity (Va), determining the maxi-mum pipe velocity (Vm) with the equation (3-21), and determining the pressure loss (Ps) with equation (3-22). The pressure surge value can be calculated using the equation (3.23).

In Table 4.8 the following are the results of the calculation of the pressure surge in Field L:

Table 4.8
Pressure Surge in Field L

Well	Depth	N	k	Ploss Total	Psurge
	Ft TVD			psia	psia
Z-5	928	0,41	4,22	7,27	441,57
Z-5	1104	0,41	4,22	5,38	522,05
Z-10	409	0,51	3,10	4,36	195,77
Z-10	800	0,51	3,10	5,14	387,86
Z-12	1998	0,38	6,44	27,07	982,91
Z-12	2325	0,38	6,44	27,63	1152,00
Z-13	2531,5	0,52	2,64	22,47	1246,70
Z-13	2614,4	0,52	2,64	22,47	1273,20

In the Z-5 well at a depth of 928 ft TVD and 1104 ft TVD loss circulation occurs, therefore, countermeasures are carried out so that the loss does not occur again.

When making holes 17 - 1/2” at a depth of 928 ft TVD found a dynamic loss of 400 bpd. Handling is done by stopping the pump and observing a static loss of 120 bpd. Then mixing 50 bbls stop loss, pump again with 20 bbls Hi-Vis + 50 bbls stop loss + 10 bbls Hi-Vis. When the stop loss is immersed for 1 hour the well is observed to be static, then the bit is removed until the shoe is 30” Conductor pipe at a depth of 380 ft MD, and the pump pressure is raised again to 1000 gpm so that dynamic loss does not occur again.

While continuing to make holes 17 - 1/2” at a depth of 1104 ft TVD, there was a total loss of circulation. The initial treatment was to lower the pump pressure from 900 gpm to 300 gpm. After observing the loss to 395 bpd. The next treatment is by pumping the LCM (20 ppb Fibroseal M + 20 ppb CaCO3 M), then increasing the pump pressure to 1000 gpm so that dynamic loss does not occur again.

In the Z-10 well at a depth of 409 ft TVD and 800 ft TVD loss circulation occurs, therefore, countermeasures are carried out so that the loss does not occur again. At a depth of 409 ft TVD, a dynamic loss of 200 bpd was found. The treatment was carried out by pumping 50 bbls LCM (20 ppb CaCO3 M + Fibroseal M) 3 times and performing Cement Plug 3 times. The first cement plug was carried out by pumping 10 bbls of seawater and 110 bbls of cement slurry. The second cement plug is carried out by pumping 10 bbls of seawater and 140 bbls of cement slurry. The third cement plug is carried out by pumping 172 bbls of cement slurry, so that the lost circulation can be overcome and the hole making can be resumed. At a depth of 800 ft TVD a dynamic loss of 300 bpd occurs. Handling is done by lowering the pump pressure to 400 gpm, but the loss of circulation only decreases slightly to 270 bph. Then re-spot LCM (20 ppb CaCO3 M + 30 ppb Fibroseal M and perform a cementing plug with a composition of 10 bbls sea water +170 bbls cement slurry so that lost circulation can be overcome.

In the Z-12 well at a depth of 1998 ft TVD and 2325 ft TVD loss circulation occurred, therefore countermeasures were carried out to prevent the loss from occurring again. When making a 12-1/4 hole from a depth of 2440 ft to 2827 ft MD/2048 ft TVD with a pump pressure of 850/900 gpm, a dynamic loss at a depth of 1998 ft was found at 60 bpd. The handling is done by reducing the flow rate from 930 gpm to 900 gpm, after observing that there is no static loss. And when reducing the flow rate again to 850 gpm the dynamic loss was successfully overcome so that the hole making could be resumed. The depth that experienced the next loss of circulation was a depth of 2325 ft TVD. At this depth there is a dynamic loss of 60 bpd, by pumping the LCM and reducing the pump pressure to 850 gpm, the loss of circulation has been overcome.

In the Z-13 well at a depth of 2531.5 ft TVD and 2614.4 ft TVD loss circulation occurs, therefore countermeasures are carried out so that the loss does not occur again. At a depth of 3667 ft MD / 2531.5 ft TVD total dynamic loss was found, so a cement plug was performed by pumping 5 bbls DW spacer and test lines up to 1000 psi. The circulation is stopped slowly until the pump pressure becomes 200 gpm and the pump rate is raised again to 800 gpm so that the loss can be overcome. Dynamic loss was initially 93 bpd at 3632 ft depth and increased to 120 bpd at 3667 ft MD. By lowering the pump pressure, the loss of circulation at this depth can be overcome. The next depth that experienced loss of circulation was 2614.4 ft TVD, found a dynamic loss of 79 bpd so a cement plug was performed by pumping 5 bbls DW spacer and test lines up to 1000 psi. The next step is to lower the pump pressure to 850 gpm so that the dynamic loss at this depth can be overcome.

Conclusions

Some of the conclusions obtained from the results of this research that have been carried out are as follows:

1. Based on the depth analyzed in field L, the types of losses that occur are partial loss and total loss. By lowering the pump pressure, pumping out lost circulation material (Fibroseal and CaCO3), and performing a cementing plug so that the lost circulation at any depth in the L field was successfully overcome.
2. Based on the leak off test (LOT) data conducted on the Z-5 well, the formation will fracture at 10.91 ppg. While the LOT carried out on the Z-10, Z-12, and Z-13 formations will fracture at 16.91 ppg, 11.49 ppg, 11.07 ppg. The leak off test data is used as an evaluation limit of the ECD and BHCP values.
3. The addition of mud density called equivalent circulating density in the Z-5 well at a depth of 928 ft TVD is 9.13 ppg and at a depth of 1104 ft TVD is 9.08 ppg. Meanwhile in the Z-10 well at a depth of 409 ft, which is 9.17 ppg and at a depth of 800 ft, TVD is 9.30 ppg. So it can be interpreted that the ECD value in the Z-5 well and the Z-10 well does not exceed the maximum mud density value limit.
4. The formation fracturing pressure found in the Z-12 well at a depth of 1998 ft is 1160.84 psia and at a depth of 2325 ft is 1329.37 psia. Meanwhile, the value of the formation fracture pressure in the Z-13 well at a depth of 2531.5 ft is 1446.23 psia and at a depth of 2614.4 ft is 1472.73 psia.
5. In the Z-12 well, the pressure caused by the addition of mud density (BHCP) at a depth of 1998 ft is 979.04 psia and at a depth of 2325 ft the BHCP value is 1148.05 psia. Meanwhile, in the Z-13 well, the BHCP value at a depth of 2531.5 ft is 1242.41 psia and at a depth of 2614.4 ft the BHCP value is 1268.90 psia. This indicates that the BHCP value for each depth does not exceed the fracture pressure of the existing formation.
6. In wells Z-5 and wells Z-10 circulation is lost due not to mechanical factors but due to the type of formation. The type of formation is the Cisubuh Formation with its rock lithology, namely clay-stone which has large pores and is interconnected, causing loss of circulation.
7. Based on the results of calculations that have been carried out on wells Z-12 and wells Z-

13, that the loss of circulation is not due to the weight of the mud, pumping pressure and even pressure surges, but is caused by the formation, namely the Parigi formation with limestone rock lithology. has a large and interconnected porosity that can cause drilling fluids to be lost into the formation.

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