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Management Of Shallow Gas Kick At Well SYH-05 In West Java Area

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ABSTRACT

SYH-05 Well Drilling Operation West Java Area, was planned to be drilled with a final depth of 1694.65 mMD / 1500 mbpl by directional well drilling. Drilling hazards on the 17½" trajectory were shallow gas, gumbo, and bit balling. Furthermore, on this trajectory, shallow gas handling and optimization of drilling were going to be executed through shallow gas kick countermeasures in the SYH-05 Well. The high gas readings from the SYH-03 Well and the SYH-04 Well are 867 units and 1275 units, respectively, at a depth of 500-520 mMD intervals.
After carrying out mitigation for shallow gas mitigation, the SYH-05 Well would use a higher Mud Weight than the reference well in this study starting with MW 1.12 SG while the reference well started with MW 1.08 SG, and the use of Annular – Single Ram 21-1/ 4" 2K with 10" Ball Valve as Diverter System. Moreover, to overcome the Kick Volume which was larger than the 17-1/2" hole, a 12-1/4" Pilot Hole would be installed. Prepare High Density Mud as a Contingency Plan and 4 Mud Pumps to anticipate the implementation of High Flow Rate Dynamic Kill. In the Cementing Design process, Gas Tight Slurry Cement would be applied.
Based on the Casing Setting Depth analysis in the SYH-05 well drilling operation, there were 4 trajectories, namely: Conductor Casing 20", 0-80m; Surface Casing 13-3/8", 80-663.69m; Production Case 9-5/8", 663.69-1060m; and Production Liner 7", 1060.50-1694.65m. The implementation of Well Control was aimed to tackle the shallow gas kick was successfully executed in less than 1 hour without incident or accident. Work on the 17-1/2" trajectory which was a shallow gas zone could be done with the planned timetable.

Keywords: Drilling hazard, Shallow gas kick, Optimization, Countermeasures.

I. INTRODUCTION

Geological disasters often occur during oil and gas drilling. This is certainly very detrimental to the oil and gas industry, because it can cause enormous material losses including loss of life. Drilling accidents are very dangerous and become a basic problem due to lack of adequate information, the oil and gas industry spends more time and money analyzing how to find reservoirs for hydrocarbon production, without knowing how to mitigate disasters caused by construction damage and explosions (blow out). which is likely to endanger safety when drilling exploration wells.

High-resolution seismic surveys are the main anticipatory measure carried out before drilling exploration wells and installing construction rigs to find geohazard zones. The most dangerous geohazard zones are channels (subsurface canals) and gas pockets, which can cause drilling rig instability and blow out during oil and gas drilling.

Identifying Shallow Gas using seismic is very important in petroleum exploration and production. Identification and mitigation of shallow gas is the main objective in well planning. Shallow Gas can be identified based on amplitude anomaly, push-down effect, and low frequency.

The drilling operation of the SYH-05 Well, will be drilled with a final depth of 1694.65 mMD / 1500 mbpl with the type of well drilling is directed (Directional). Drilling hazards on the 17" route are shallow gas, gumbo, and bit balling. Furthermore, on this route, shallow gas handling will be carried out and optimization of drilling through shallow gas kick countermeasures in the SYH-05 Well.

II. METHODS

This study is intended to optimize the drilling operation of the SYH-05 Well, based on the history of drilling in the SYH-03 and SYH-04 wells where there are indications of shallow gas which can cause the drilling program to be hampered, high operating costs, worker safety, production delays. wells, company reputation and impact on the environment.
The hypothesis or expected result of this research is that the operational activities of the SYH-05 Well drilling can run safely and no fatalities occur based on the evaluation results of the SYH-03 Well and the SYH-04 Well as a reference.
Research with the title Drilling Optimization Through Shallow Gas Kick Management at the SYH-05 Well in West Java Area uses a research approach with analytical descriptive method. The research data collected from the field will then

be analyzed by examining each drilling and subsurface parameter. A study of the drilling operations of 2 reference wells SYH-03 and SYH-04 was carried out which would then be applied to the SYH-05 well drilling. After further discussion, conclusions are drawn which are the answers to the research objectives.

III. RESULTS AND DISCUSSION

3.1. Well Technical Data

The SYH-05 well being drilled has the following characteristic data:

Table 1. SYH-05 Well Data

Well Name	SYH-A5
Well Location	SYH-05
Well Clasification	Exploitation Drilling
Well Type	Directional
Ground Level (GL)	13473m from sea level
Drill Floor Height	6.1 from GL
KOP	100 m
Azimuth	N 120.71 E / 29.53 deg
Horizontal Displacement @ TD	694.93 m
Rig/Drilling Contractor	750 HP
Drilling Purpose	Development Well from C1
Main Target	Layer 1
End of Depth	1694.65 mMD/150 mVDSS
Estimation of Work Day	39.1 days
Estimation of Completion	26.5days

Table 2. Data for Trayek 17-1/2"

Plan Casing Point	664 m
Interval Depth	584 m
BOP System	Annular – Single Diverter 21-1/4"2K
Drilling Hazard	Shallow gas, Gumbo, Bit Balling
Mud System	KCL 7% - Polymer 3%

3.2. Estimation Of Prospect Layers And Peak Layers

The SYH-05 well drilling aims to increase the absorption point of hydrocarbons in the reservoir layer of the C1 layer limestone in the Upper Cibulakan Formation (CBA). This well is planned to be drilled directionally from the SYH-01 cluster. From the results of the drilling of the SYH-03 development well, with a production of 145 bopd, 2,666 blpd from Layer C1 (Upper Cibulakan). The drilling is planned to take place within 39.1 days of operation (well basis and completion) with the implementation as effective and efficient as possible, without work accidents, equipment damage and environmental damage as well as increasing production gains.

Table 3. Prospect Layer and Peak Layer

Layer Name	mTVDSS	Thickness	Target	Composition
C1	992	30	Oil	CO_2 1-4%
C2	1048	11	Gas	CO_2 43%
F	1237	6	Gas	CO_2 43%

3.3. Well Track Profile Plan

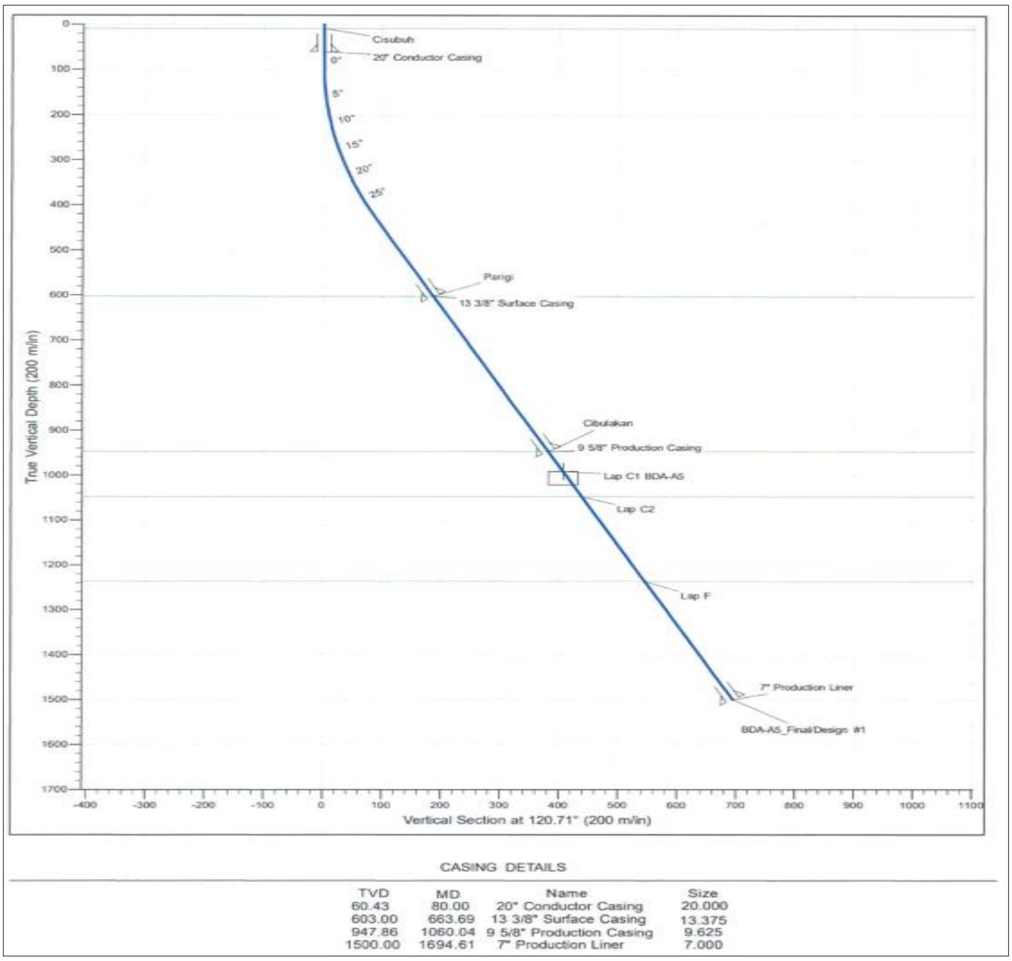

Figure 1. SYH-05 Well Trajectory Profile

3.4. Identification Of Shallow Gas Hazards From Reference Well Data

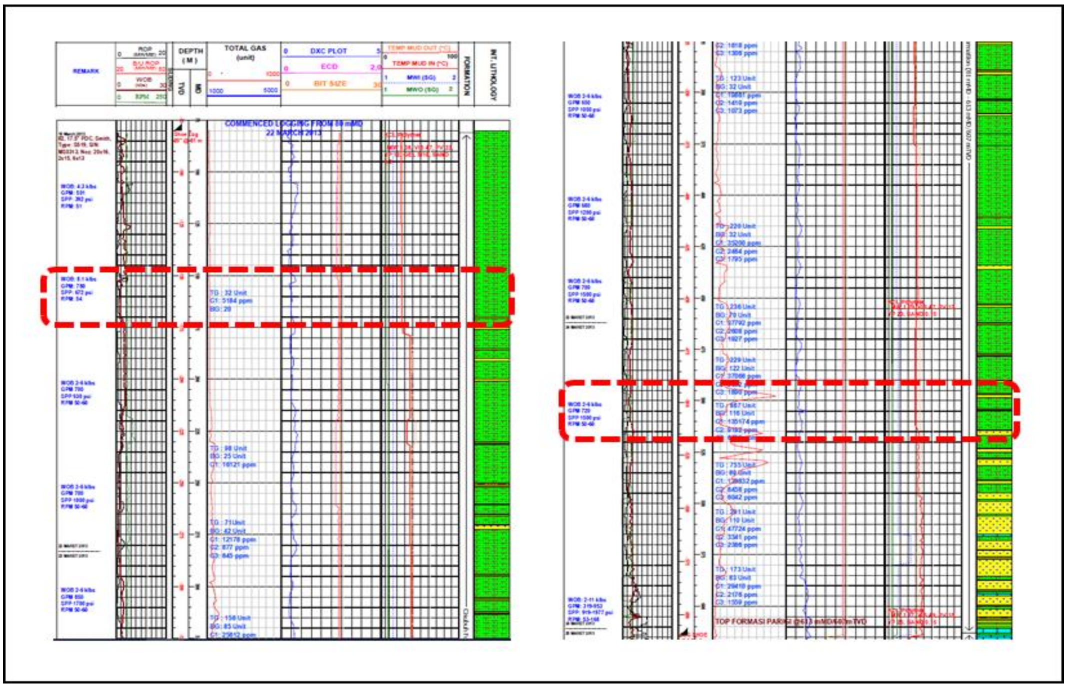

Figure 2. Reff Mudlog of the SYH-03 Well

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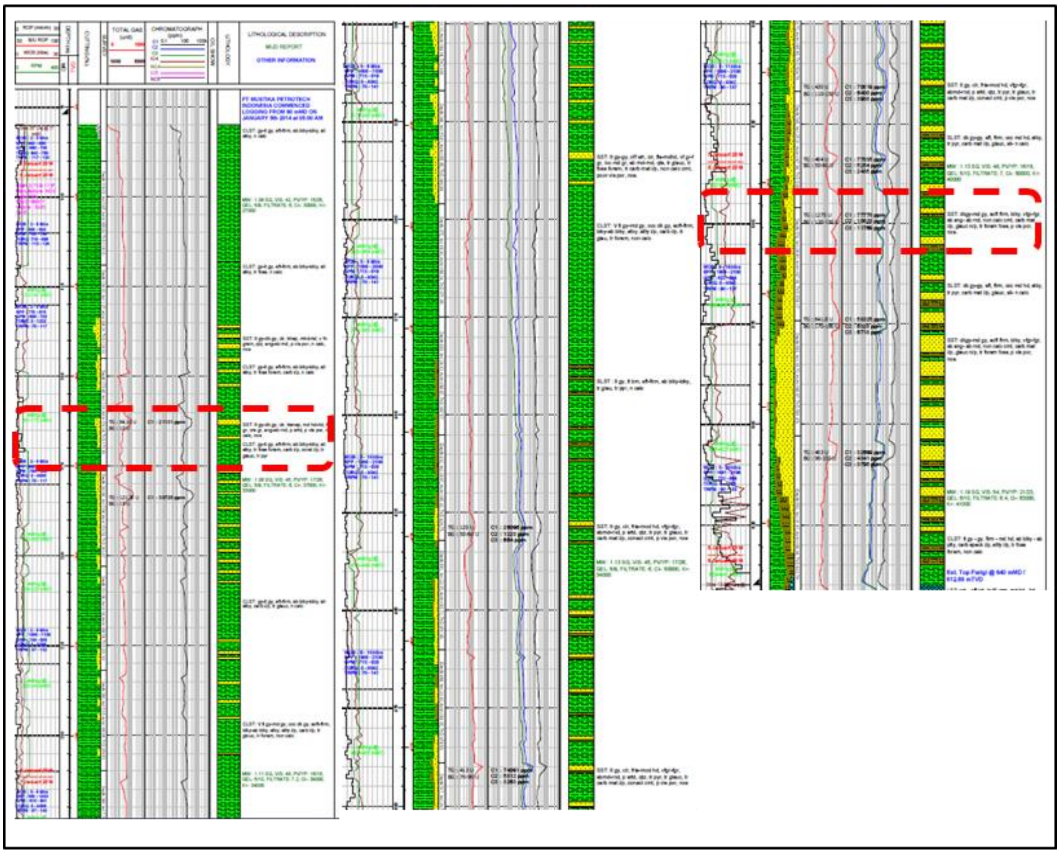


Figure 3. Reff Mudlog of the SYH-04 Well

The high gas reading in Figure 2 is recorded at 867 units at a depth of 500 -525 mMd intervals and Figure 3 is recorded at 1275 units at a depth of 500 -525 mMd intervals.

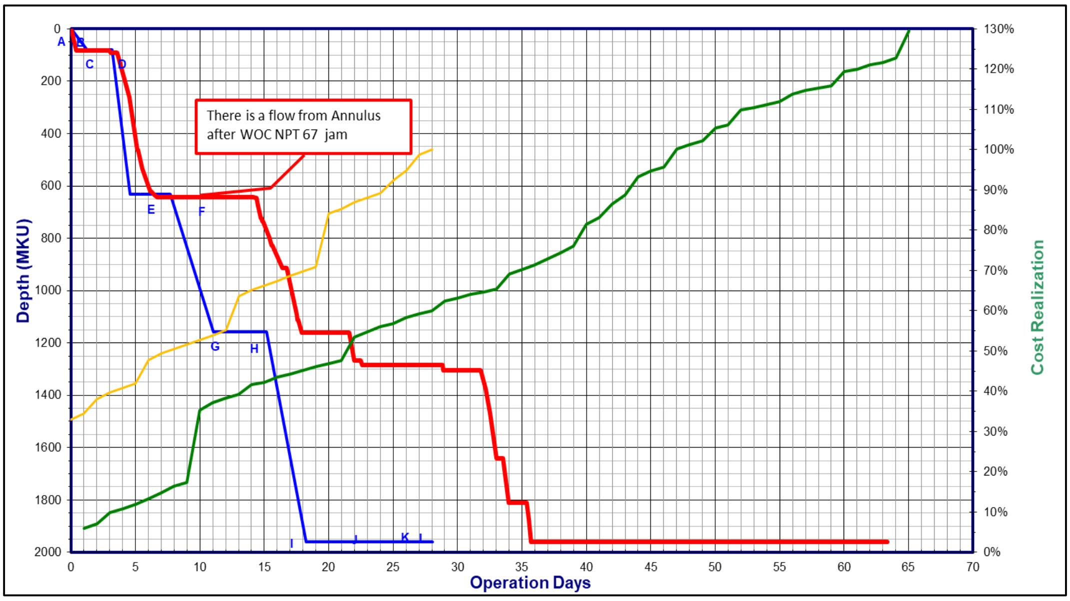


Figure 4. Information on activities at the SYH-04 Well

3.5. Identification Of Shallow Gas Hazards From Surface Indications

Based on the identification on the surface, there are active and inactive gas burst points. The last gas burst recorded in early 2018 was estimated to be from a depth of 100-200 m and less than 1 km from the location of the SYH-02 Well.

3.6. Cementing

Cementing is closely related to drilling operations, where the success of cement planning is one of the success factors in the drilling process. Cementing in drilling wells is a process of mixing and displacing cement slurry through the casing and flowing up through the annulus behind the casing so that the casing is bonded to the formation. According to the reasons and objectives, cementing can be divided into two, namely Primary Cementing and Secondary Cementing or Remedial Cementing.

- Primary Cementing is the first cementing done after the casing is lowered into the well.
- Secondary Cementing is re-cementing to complete Primary Cementing or repair damaged cement.

3.7. Cement Method

Based on the method used, the cementing process can be divided into two types, namely single stage cementing and dual stage cementing.

- Single Stage Cementing

Single stage cementing is generally used for cementing conductor pipes and surfaces. A certain amount of sludge is prepared and pumped into the casing. It should also be noted that all internal parts of the casing equipment, including the float shoe, float collar and so on are tools that can easily be destroyed if drilled.

- Dual Stage Cementing

Dual stage cementing is applied to cementing long series of casings specifically for:

a. Reduces total pumping pressure.

b. Reducing the total hydrostatic pressure on weak formations so that no fractures occur or form.

c. Allows cementing of the entire total length of the casing;

d. Ensures effective cementing around the shoe of the previous casing.

3.8. Volume Total Slurry Cement

This calculation is usually based on the size of the hole diameter plus an additional volume called the excess volume, usually based on field experience (generally 10% - 25%). However, in this well, the required excess volume is 100% which is obtained from the available data.

This calculation allows the service company to determine the total volume of slurry cement required to mix and pump the cement slurry and push it into the annulus. The following is the equation used:

1. Volume Annular ID Casing 20" & OD Casing 13-3/8”

$$V1 = Capacity\ 1 \times (DTOL - Dcsg\ 20'') \quad (1)$$

$$Capacity\ 1 = \left(\frac{(ID\ CSG\ 20'')^2 - (OD\ CSG\ 13\text{-}3/8'')^2}{1029.4}\right) \quad (2)$$

2. Volume Annular OH 17-1/2” & OD CSG 13-3/8”

$$V2 = Capacity\ 2 \times (Dflatshoe - Dcsg\ 13\text{-}3/8'') \quad (3)$$

$$Capacity\ 2 = \left(\frac{(OH\ 17\text{-}1/2'')^2 - (OD\ CSG\ 13\text{-}3/8'')^2}{1029.4}\right) \quad (5)$$

3. Volume ID Casing 13-3/8”

$$V3 = Capacity\ 3 \times (Dfloatcollar - Dfloatshoe) \quad (6)$$

$$Capacity\ 3 = \left(\frac{(ID\ CSG\ 13\text{-}3/8'')^2}{1029.4}\right) \quad (7)$$

4. Volume Rat Hole

$$V4 = Capacity\ 4 \times (Dfloatshoe - Dwell) \quad (8)$$

$$Capacity\ 4 = \left(\frac{(OH\ 17\text{-}1/2'')^2}{1029.4}\right) \quad (9)$$

5. Volume Annular OH 17-1/2” & OD Casing 13-3/8” Excess

$$V5 = Capacity\ 5 \times (Dflatshoe - Dcsg\ 9\text{-}5/8) \times 100\% \quad (10)$$

$$Capacity\ 5 = \left(\frac{(OH\ 17\text{-}1/2'')^2 - (ID\ CSG\ 13\text{-}3/8'')^2}{1029.4}\right) \quad (11)$$

6. Volume Total Cement Slurry

$$TCS = V1 + V2 + V3 + V4 + V5 \quad (12)$$

3.9. Shallow Gas

Gas that is from a depth of 0 to 1,000 meters below the seabed is defined as shallow gas which can be carbon dioxide (CO_2), hydrogensulphide (H_2S) and ethane (C_2H_6) but most of it is methane (CH_4). Shallow gas comes from the decay of bacteria and marine organisms that are deposited several meters below the seabed and can even be buried up to hundreds of meters during the decay process, the gas formation process can continue to a depth of 300-400 meters

which in the end continues to be deposited to a depth of 1,000 meters. (Holmes, 1997). The presence of gases can be divided into three, namely:
1. As a gas dissolved in water.
2. As an insoluble gas and in the form of bubbles (bubble).
3. As gas hydrate.

Gas Inflow State		Slight Flow	Bubble Flow	Slug Gas Flow	Annular Gas Flow
Gas Inflow Rate in	in sm^3/s	< 10	10-100	100-270	>270
wellbore	or in 10^3 sm^3/h	< 36	36-360	360-980	>980
Corresponding mud flow volume at wellhead	m^3	<0.1	0.1-1	1-2.7	>2.7
SG hazard classification		Slight Gas Invasion	Early gas kick	Gas kick	Serious well blowout

Figure 6. Shallow Gas Hazard Classification

The characteristics of shallow gas hazard are:
1. Slight flow (slight gas invasion).
Gas begins to flow into the wellbore, difficult to monitor at the wellhead. Less than 0.1 m3 drilling mud overflows the wellhead during the time of gas invasion. This happened because during the drilling through the shallow gas zone the size was small with a formation pressure coefficient of less than 1.15.
2. Bubble flow (early gas kick).
Gas invasion is taking place, which can cause an early gas kick and between 0.1-1 m3 drilling mud within a short period of time from the wellbore annulus can be observed in the wellhead. In this condition, about 10-100 sm3/s gas can flow into the wellbore, mixed and compressed in the drilling fluid so as to reduce the density of the mud. This happens because during drilling through a medium-sized shallow gas zone with a formation pressure coefficient of more than 1.2 which can cause a gas kick or blowout.
3. Slug gas flow (gas kick).
The relatively large volume of gas (100-270 sm3) gushing into the wellbore can effectively displace the liquid in the wellbore and cause gas slug and gas kick.
4. Annular gas flow (major or serious well blowout).
This occurs when the velocity of gas entering the wellbore is greater than 270 sm3/s and almost all of the fluid in the wellbore is replaced by gas invasion. This can occur when drilling through large shallow gas zones with high formation pressure coefficients.

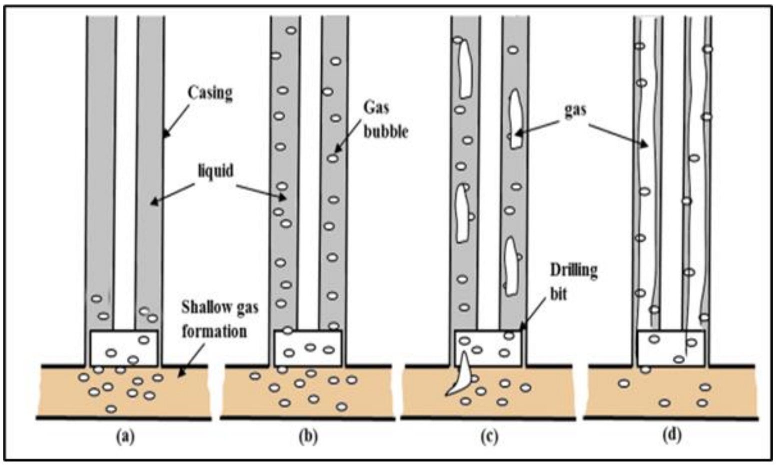


Figure 7. Shallow gas flow patterns with different levels: (a) Slight Flow, (b) Bubble Flow, (c) Slug Gas Flow, and (d) Annular Gas Flow

3.10. Well Kick Shallow Gas

Well kick is an event where formation fluid enters the borehole during drilling operations, kicks can occur when drilling is being carried out or not. Kicks can occur during drilling due to the failure of the primary well barrier in the form of mud density and the secondary well barrier in the form of pump pressure on the concept of well integrity, so that the hydrostatic pressure and the resulting hydrodynamic pressure are smaller than the formation pressure.

3.11. Shallow Gas Hazard Mitigation

Planning:

1. Higher MW usage compared to reference wells, starting with MW SG 1.12. (ref well using MW starting from SG 1.08). Use of Annular-Single Ram 21-1/4" 2K with 10" Ball Valve as Diverter System.
2. Use of pilot hole 12-1/4" to anticipate a larger kick volume compared to hole 17-1/2".
3. Prepare high density mud as a contingency plan. Prepare 4 mud pumps to anticipate the implementation of high flow rate dynamic killing.
4. Prepare water sources for mud tanks and reserve pits. Prepare the mud to the maximum capacity of the mud tank during the drilling of the 12-1/4" pilot hole.
5. The use of gas tight slurry cement design.

3.12. Casing Setting Depth

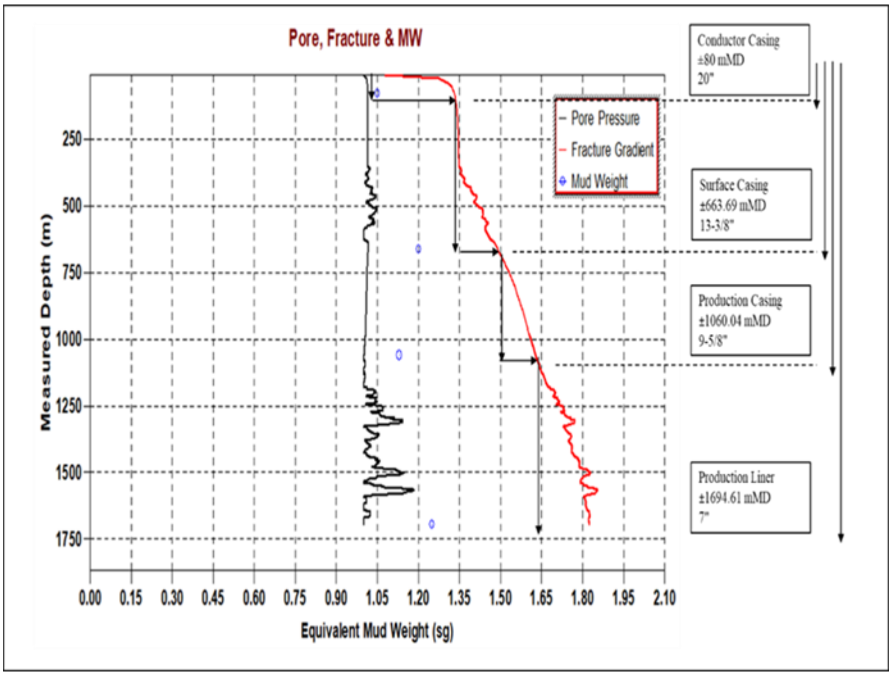


Figure 8. Casing Depth Setting Depth interval

Based on the analysis of Figure 7 in the drilling operation of the SYH-05 Well, there are 4 traject:
1. Conductor Casing 20", 0 – 80 meters.
2. Surface Casing 13-3/8", 80 – 663.69 meters.
3. Production Casing 9-5/8", 663.69 – 1060 meters.
4. Production Casing 9-5/8", 663.69 – 1060 meters.

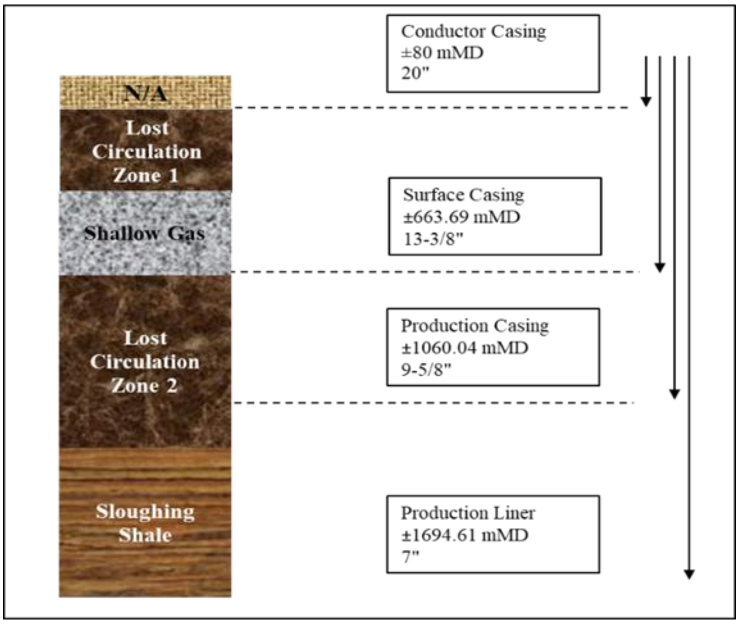


Figure 9. Casing Design and Drilling Hazard Potential

Indications of the danger of shallow gas in the reference wells were recorded at intervals of 500 – 525 mMD, after conducting a study in an effort to overcome the problem of shallow gas, the handling was carried out using a 12-1/4" Pilot Hole to overcome a larger kick volume compared to holes 17-24. 1/2", and Kill Well and Divert Procedure to anticipate the implementation of high flow rate dynamic kill.

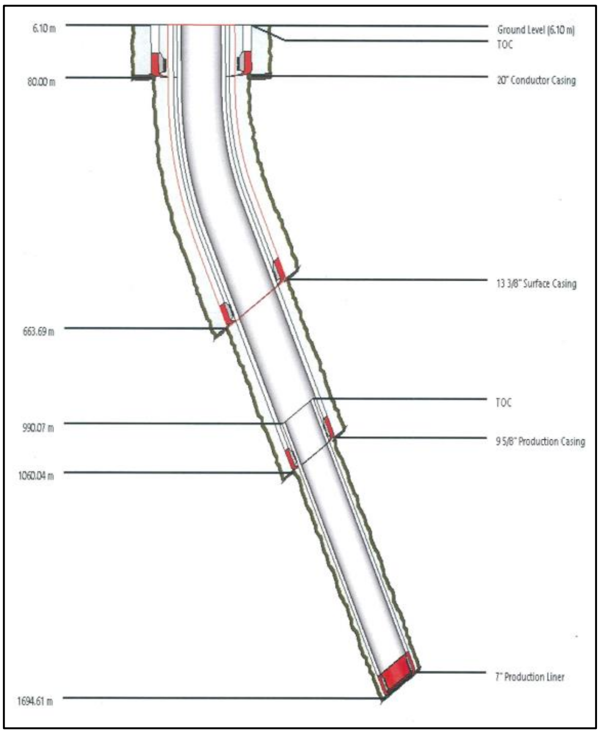
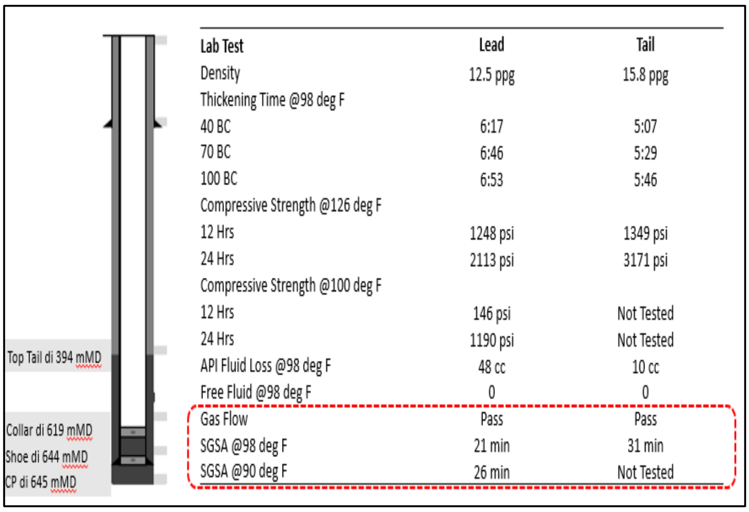


Figure 10. Well design SYH-05



Lab Test	Lead	Tail
Density	12.5 ppg	15.8 ppg
Thickening Time @98 deg F		
40 BC	6:17	5:07
70 BC	6:46	5:29
100 BC	6:53	5:46
Compressive Strength @126 deg F		
12 Hrs	1248 psi	1349 psi
24 Hrs	2113 psi	3171 psi
Compressive Strength @100 deg F		
12 Hrs	146 psi	Not Tested
24 Hrs	1190 psi	Not Tested
API Fluid Loss @98 deg F	48 cc	10 cc
Free Fluid @98 deg F	0	0
Gas Flow	Pass	Pass
SGSA @98 deg F	21 min	31 min
SGSA @90 deg F	26 min	Not Tested

Figure 11. Cementing Program Well SYH-05

3.13. 17-1/2" Traject Drilling Activities

Drilling on the 17-1/2" route will start on June 13, 2021 at 00.00 WIB using a 12-1/4" pilot hole at 84 mMD to 186.4 mMD. At the time of drilling a kick occurred with a total reading gas of 2,100 units. Kick handling procedure:

1. Divert the flow and do an open circulation. Burn the gas in the flare.
2. Pump high density mud 130 bbls for fast dilute mud to MW SG 1.22. Continue pumping the SG 1.22 mud at a flowrate of 1000 gpm of 400 bbls. Gas flow is reduced until it stops during pumping.
3. Continue normal circulation to the mud tank while observing gas reading, all parameters are normal.
4. Continue to drill the pilot hole oriented formation from 186.4 mMD spi 647 mMD (Casing Point).
5. Unplug the 12-1/4" + BHA Directional circuit to the surface.
6. Enter and enlarge pilot hole 12-1/4" to 17-1/2" with 12-1/4" x 17-1/2" BHA Under-reamer to 645 mMD.
7. Entry and cementing of 13-3/8" Casing.
8. WOC.

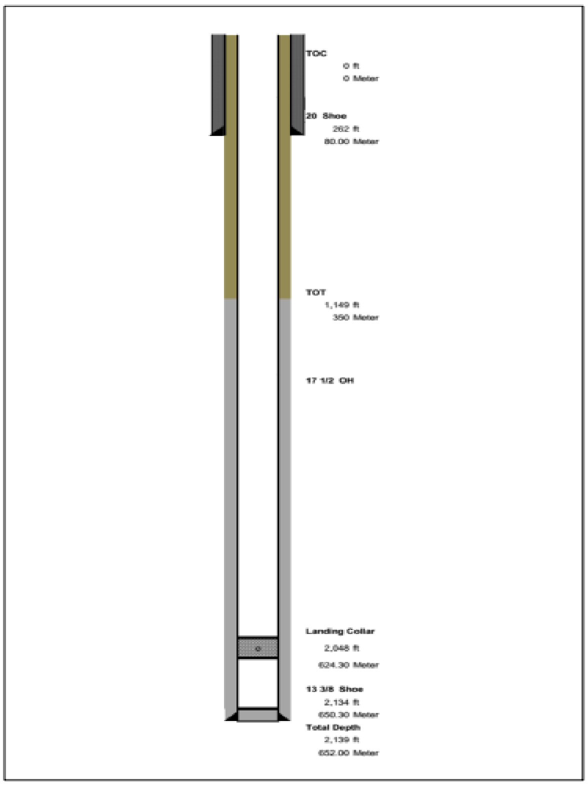


Figure 12. Design of the 17-1/2" Route 13-3/8" Case

3.14. Cementing Program Trayek 17-12”

Well Data					
Exist Casing	: 13.375 inch	Weight	: 54.5 ppf	I.D	: 12.615 inch
Open Hole	: 17.50 inch	T.O.C	: --- feet	T.O.T	: 1,149 feet

Volume Calculation				
CSG - CSG (L)	: 1.0190 cuft/ft	x	262 feet =	267 cuft
CSG - OH (L)	: 0.6946 cuft/ft	x	887 feet =	1,232 cuft
CSG - OH (T)	: 0.6946 cuft/ft	x	964 feet =	1,367 cuft
Shoe Track (T)	: 0.8679 cuft/ft	x	85 feet =	74 cuft
Rat Hole (T)	: 1.6703 cuft/ft	x	6 feet =	19 cuft
Total Volume	:			2,959 cuft

Total Mix Water		
Lead Slurry	: 6.490 gps	163 bbl
Tail Slurry	: 4.050 gps	132 bbl

Total Slurry	
Lead	: 267 bbl
Tail	: 260 bbl

Total Mix Fluid		
Lead Slurry	: 9.480 gps	193 bbl
	Dead Volume	45 bbl
Tail Slurry	: 5.430 gps	157 bbl
	Dead Volume	20 bbl

Material Requirement				
Additives/ Product	Lead Slurry : 13.80 ppg		Tail Slurry : 15.80 ppg	
	Concentration	Total	Concentration	Total
Cement		857 sack		1,217 sack
EC-1	% BWOC	0.0 lbs	4.000 % BWOC	3,428.0 lbs
A-7	1.000 % BWOC	806.0 lbs	% BWOC	0.0 lbs
FP-9LS	0.080 gps	69.0 lbs	0.050 gps	61.0 lbs
A-3L	0.350 gps	300.0 lbs	gps	lbs
CD-37LS	0.100 gps	86.0 lbs	0.080 gps	98.0 lbs
FL-47LS	1.300 gps	1,115.0 lbs	1.200 gps	1,461.0 lbs
BA-58L	1.500 gps	1,286.0 lbs	1.400 gps	1,104.0 lbs
R-28L	0.160 gps	138.0 lbs	0.015 gps	19.0 lbs

Preflush	CD-37LS	0 bbl	ppg
Spacer	MSC-Spacer	70 bbl	MW + 1 ppg
Scavenger	Cement	0 bbl	ppg
Displacement	WBM	317 bbl	MW ppg

Total Material Requirement					
Product	Lead	D.V.45 bbls	Tail	D.v 15 bbls	Total
Cement	857		1,217		2,429
EC-1	0	0	3,428	620	4,048
A-7	806	200	0	0	1,006
FP-9LS	69	16	61	8	154
A-3L	300	70	0	0	370
CD-37LS	86	20	98	13	217
FL-47LS	1,115	260	1,461	186	3,022
BA-58L	1,286	300	1,704	217	3,507
R-28L	138	32	19	3	192

Figure 12. Cementing Calculation Trayek 17-1/2”

Table 4. Details of Cementing Activity Parameters

Pumping Schedule	Rate	Pressure
100 bbls Lo-Vis Mud	4 BPM	300 psi
70 bbls Spacer SG 1.38 – Drop Bottom	6 BPM	360 psi
Mix and Pump 238 bbls Lead Cement SG 1.50 – Drop Top Plug	5 BPM	600-640 psi
Mix and Pump 168 bbls Tail Cement SG 1.90 – Drop Top Plug	5 BPM	800-850 psi
Displace with 314 bbls Mud SG 1.22	4.5 BPM	180-400 psi
Bump Plug		1000 psi

3.15. Well Control Procedure

1. Perform the Well Control procedure by diverting the flow from the well by opening the 10” ball vale and closing the pipe ram.
2. Pumping high density mud 130 bbls for fast dilute to increase the mud weight in the system from 1.12 to 1.22.
3. Continue to pump SG 1.22 mud with a rate of 1000 GPM, 400 bbls (est two times the volume of the hole).
4. During the pumping process, the gas flow decreases until it stops.
5. After 100% mud return, flow is returned to flowline and monitoring gas reading, mud flow out and gain/loss via straight circulation.
6. Gas reading stays below 100 units, Mud Flow Out is stable and no gain/loss is obtained.

IV. CONCLUSION

Hazard identification and mitigation are important factors in overcoming the potential for shallow gas in the SYH-05 Well. The Well Control implementation to tackle the shallow gas kick was successfully carried out in less than 1 hour without incident or accident. Work on trayek 17-1/2" which is a potential shallow gas zone can be carried out with the planned timetable.

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