Drilling Casing Design using Drilling Software at Well "Well X-01" Field "S" Check for

KRT. Nur Suhascaryo, Sulistyorini Widi Hastuti, Eko Suyanto

Abstract: Well "X-01" is a slant (J-Type) directional well and will be subjected to appropriate and technically qualified drilling casing planning to prevent problems such as burst, collapse, and tension that can cause increased internal and external pressure loads experienced by the casing. The methodology used in this research is a combination of document study and quantitative analysis in casing planning, utilising Drilling Software to account for the loading acting on the casing, which includes burst, collapse, tension, biaxial, and triaxial loads. Casing design planning for Well "X-01" is carried out by analysing the casing setting depth based on PPFG data, considering kick tolerance. Then, casing planning is carried out using Drilling Software. The results of drilling casing planning in Well "X-01" Field "S" using Drilling Software, five design routes were obtained, that is conductor casing using X-52 casing; 157.5 ppf, surface casing using K-55 casing; 94 ppf, intermediate casing using K-55 casing; 54.5 ppf, kick tolerance 32.55 bbls, production casing using K-55 casing; 40 ppf, kick tolerance 42.1 bbls, and production liner using K-55 casing; 23 ppf, kick tolerance 69.08 bbls. The safety factor of each route met API standards for the durability of the selected casing. In well "X", casing planning can serve as a reference point in the casing design process stage, as optimal and safe results are achieved.

Keywords: Total Loss, Kick, Drilling Software

I. INTRODUCTION

Well "X-01" is a planned production well located in the "S" field, Prabumulih, South Sumatra. Well "X-01" is a directional drilling well with an inclined trajectory type (J-Type) at a final depth of 5638.45 ftMD or 5544.61 ftTVDSS. In Well "X-01", drilling casing planning is necessary to prevent burst, collapse, and tension problems, thus providing a level of safety during the drilling process until the production stage (Hendri Kurniantoro, 2015, [1]).

The influential factors in casing planning are casing diameter, casing length, resistance to pressure, and load on the casing (burst pressure, collapse, and tension) with the

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target of achieving the most significant safety factor number, to obtain the strongest and safest casing set (Noviandy, 2015, [2]). Casing planning for Well "X-01" was conducted by considering the stratigraphic layer, fluid type, and formation pressure.

In this research, " Drilling Casing Design Using Drilling Software at Well "X-01" Field" consisting of 5 (five) drilling routes has been carried out. The kick problem is a requirement for the calculation of kick tolerance to optimize the depth point of casing placement, in addition to being able to determine the amount of kick volume that can be handled before fracturing the formation (Putri, 2019, [3]). Data processing on Well "X-01" Field "S" includes depth, pore pressure, fracture gradient, LOT (Leak of Test), and correlation of nearby wells.

Based on this data, a mud window curve was created to determine the casing setting depth. Casing planning takes into account burst, collapse, and tension loads applied in Drilling Software by inputting drilling program data (in the form of pore pressure fracture gradient (PPFG) data, casing and tubing schematics, and kick tolerance) to obtain a final result in the form of a technically safe safety factor.

The findings of this research are expected to provide an alternative casing design for achieving efficient, accurate, and safe results in the implementation of further drilling in the field.

II. MATERIAL AND METHODOLOGY

The methodology used in this research is document study and casing planning using Drilling Software. First, the participatory observation method is used to collect exploration field data for Well "X-01". The collected data include field geographical data, field geological conditions, field stratigraphy, location name, well name, well type, and drilling implementation data for each route. Additionally, the data include PPFG (Pore Pressure Fracture Gradient) data, as well as the selection of wellbore size and drill bit, along with the mud and cement program.

The following methodology involves a document study, summarising documents based on the results of participant observations in the form of drilling programs. This is followed by manual calculations using Excel to determine the depth of casing setting, based on mud window analysis and kick tolerance.

The final methodology involves casing planning using Drilling Software to design a suitable and technically safe casing, taking into account the loads that affect the casing. The flow chart for Well "X-01" is

shown in Figure 1.

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III. RESULTS AND DISCUSSIONS

A. Research Data

The Well "X-01" was drilled by directional drilling with an inclined trajectory type (J-Type) at a final depth of 5638.45 ftMD or 5544.61 ftTVDSS, conducted with a KOP (Kick of Point) point at a depth of 1574.8 ft with a BUR (Build-Up Rate) of 3°/100 ft and has a dip angle of 12.63°. The drilling of Well "X-01" has a production target of 250 BOPD for oil and 0.5 MMSCFD for gas, with a working time of 48 days.

Well "X-01" casing design planning begins with analyzing the casing setting depth using PPFG (Pore Pressure Fracture Gradient). Based on the PPFG results with formation pressure and fracture pressure plots, 5 (five) casing trajectories were obtained using the top to bottom method in determining depth and calculations starting from conductor casing (0 - 164 ft), surface casing (0 - 1476 ft), intermediate casing (0 - 4373 ft), production casing (0 - 4829 ft), and production liner (0 - 5638 ft).

The next stage is to analyze the calculation of kick tolerance, which then from both data will be entered into Drilling Software depth as support to get the final results, namely the design number and safety factor of 2 (two) loads acting on the casing, namely biaxial loads (burst, collapse, tension) and triaxial loads.

B. Well "X-01" Drilling Casing Planning

In planning the casing for drilling Well "X-01", the first step is to determine the casing depth setting. Then, prepare the hole geometry, determine the kick tolerance, and finally, determine the casing in the drilling software. The casing planning steps are as follows.

C. Casing Setting Depth Determination

Determination of casing setting depth using PPFG data based on formation pressure, formation fracturing pressure, and lithology in Well "X-01" (Rubiandini, 2010, [4]).

In determining the casing shoe location for each route, a safety factor based on the Poisson's ratio of the lithology of the final depth of each route, shale rock, of 0.28, was used (Oscar Molina, 2017, [5]). The results of the casing setting depth plot are shown in <u>Figure 2</u>.



Fig. 2. Casing Planning Setting Depth Well "X-01"

Based on the PPFG results with the formation pressure plot and formation fracturing pressure, 5 (five) casing routes were obtained using the top-to-bottom method in determining the depth and calculations starting from the casing conductor, where each route is as follows:

a. Conductor Casing

In conductor casing, installation is done at a depth of 0-164 ft using non-API welded casings with a borehole diameter of 36 *inches*.

b. Surface Casing

The surface casing was installed with the function of housing the BOP and wellhead (S.S. Rahman, 1995, [6]). On this route, a 26-inch hole was drilled from a depth of 0-1476 ft with a surface casing diameter of 20 inches. The surface casing penetrated the Kasai Formation layers, consisting of sandstone, coal, and reached a final depth of 1473.09 ft, where the casing shoe seat was located in shale lithology.

c. Intermediate Casing

In the intermediate casing, a $17 \frac{1}{2}$ inch hole was drilled to a final route depth of 4373.35 ft, and the casing shoe was placed at a depth of 4370 ft, with a casing diameter of 13 3/8 inches.

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The intermediate casing penetrates the Muara Enim Formation layer, which consists of sandstone and claystone. Meanwhile, the Gumai Formation consists of shale rock, making it suitable for use as a casing shoe seat.

d. Production Casing

Production casing is a series of casing installed from the productive layer to the surface (Pattillo, 2018, [7]), and drilling a 12 ¼ inches hole with a final depth of 4829.39 ft has a casing diameter size of 9 5/8 inches. The production casing penetrates the Baturaja Formation layer, which consists of limestone and marl. Limestone is suitable for use as a casing shoe seat.

e. Production Liner

In the target or productive layer, a production liner is planned to be constructed. The production liner penetrates the Talang Akar Formation layer, where reservoir rocks are found in this formation. Based on the results of the casing depth setting from the graph, the production liner is hung on the production casing at a depth of 4593.17 ft, and the casing shoe is placed at a depth of 5636.48 ft with a hole size of 8 ¹/₂ inches and a casing diameter of 7 inches.

D. Hole Geometry Determination

Determination of casing size and borehole size (Watt, 2017, [8]) is shown in Figure 3.



Fig. 3. Bit Size and Casing Selection (Source: Watt, 2017, [8])

Figure 3. The casing sizes used are 30 inches, 20 inches, 13 3/8 inches, 9 5/8 inches, and 7 inches. As for the bit sizes used, they are 36 inches, 26 inches, 17 $\frac{1}{2}$ inches, 12 $\frac{1}{4}$ inches, and 8 $\frac{1}{2}$ inches.

E. Kick Tolerance Calculation

After planning the casing setting depth, it is necessary to calculate the kick tolerance. In the conductor and surface sections, kick tolerance calculations were not performed

Retrieval Number: 100.1/ijrte.C78690912323 DOI: <u>10.35940/ijrte.C7869.0912323</u> Journal Website: <u>www.ijrte.org</u> because no formation test (LOT/FIT) was conducted. In the kick tolerance calculation, calculate the Leak of Test at the previous depth and the formation pressure at the intermediate casing (Lapeyrouse, 2011, [9]), i.e.:

LOT = $0,052 \times \text{LOT}$ before x Dbefore So that Vshoe is obtained, with the following equation: Vshoe = ((vol.gas kick DP x LOT)/formation pressure)

Based on the calculation of the kick tolerance on each route, the calculation results can be summarized in the following <u>Table 1</u>.

Table 1. Summary	Kick Tolerance	Result of Well '	'X-01"
	in Drilling Softw	vare	

KICK TOLERANCE				
Surface Casing Intermediate Hole	27,0356	bbl		
Intermediate Casing Production Hole	37,1707	bbl		
Production Casing Liner Hole	72,1502	bbl		

E. Drilling Software

In planning the casing design of Well "X-01" with Drilling Software to obtain accurate and safe results using 2 (two) types of program analysis, namely well depth analysis and casing design analysis (Knez Dariusz, 2010, [10]). Well depth analysis is the first stage in determining wells supported by field data. Casing design analysis is the second stage of selecting the casing design, supported by well depth data, PPFG data, and kick tolerance for each route.

F. Well Depth Analysis

The first stage of casing design planning is to create a project by inputting field target coordinates (latitude and longitude), then entering depth data, inclination angle, azimuth, dogleg, and BUR based on PT. Pertamina Hulu Rokan Zone 4 drilling program data. To obtain the results as shown in Table 2.

Table 2. Summary Results of Well Plan "X-01" in
Drilling Software

MD (ft)	Inc (°)	Azi (°)	Dogleg (°/100ft)	Build (°/100ft)
0	0	0	0	0
164	0	360	0	0
1476	0	360	0	0
4344	14,71	311,61	0,95	0,9
4371	13,87	309,33	3,77	-3,13
4773	14,69	310,92	0,39	0,39
5145	13,53	306,36	0,43	-0,31
5638	12,63	308,52	0,35	-0,31

G. Casing Design Analysis

Based on the results of the Well "X-01" depth data, casing design analysis is carried out to determine the appropriate casing planning by entering PPFG data and casing data (OD, hole size, hanger, shoe, TOC, and MW) to determine the well schematic. The casing design planning for each route is presented in Table 3.

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No			Hole Size	Measured Depths (ft)		Mud at Shoe	
INO.	<u>О</u> (ш)	Ivane	(in)	Hanger	Shoe	TOC	(g/cc)
1	30"	Conductor	36	0	157,5	0	1,05
2	20"	Surface	26	0	1473,1	0	1,15
3	13 3/8"	Intermediate	17	0	4370,1	0	1,2
4	9 5/8"	Production	12	0	4826,1	984,3	1,27
5	7"	Liner	8	4593,2	5636,5	4593	1,27
6	2 7/8"	Tubing		0	4790		1,031

Table 3. Casing and Tubing Scheme for Well "X-01"

Based on the results of the casing and tubing scheme, the hole geometry design of Well "X-01" Field "S" can be obtained in the Drilling Software as shown in Figure 4.



Fig. 4. Planning Hole Geometry of Well "X-01" Field "S"

Loads are acting on the casing according to the API safety factor, namely a burst of 1.1, collapse of 1.3, tension of 1.1, and triaxial of 1.25. In determining the load acting on the casing, the kick tolerance data, test pressure data, over-tensile force, green cement pressure test, mud height, run-in-hole speed, connection, and other variables are automatically updated based on the data entered. The results obtained from the drilling software are casing grade, casing joints, ellipse graphs, and safety factor values for each load.

In the conductor casing, a test pressure and green cement pressure test of 1200 psi, a hole speed of 1 ft/s, and an overdraw force of 100000 lbf were used. The surface casing used a test pressure and green cement pressure test of 1500 psi, a mud height reaching the surface assuming no kick (1473 ftMD), a hole speed of 1 ft/s, and an overdraw force of 100000 lbf. In the intermediate casing, LOT is carried out, so there are additional kick tolerance data variables based on the results of excel calculations, test pressure and green cement pressure test of 1300 psi are used, mud level reaches the surface assuming no kick occurs (4370 ftMD), running in hole speed of 1 ft/s, and overpull force of 100000 lbf. In the production casing, LOT is carried out, so there are additional kick tolerance data variables based on the results of excel calculations, test pressure and green cement pressure test of 1700 psi are used, mud level at a depth of 1312 ftMD assuming partial/total loss, running in hole speed of 1 ft/s, and overpull force of 100000 lbf. In the production liner,

LOT is carried out, so there are additional kick tolerance data variables based on the results of excel calculations, 1500 psi test pressure and green cement pressure test are used, mud level at a depth of 1804.46 ftMD assuming a kick occurs, running in hole speed of 1 ft/s, and overpull force of 100000 lbf.

H. Summary

Casing planning using drilling software obtained the value of casing grade and safety factor value for each casing load on each casing route. The safety factor for each casing route can be said to be safe because it exceeds the API SF number. The results of the analysis of each route can be summarized based on <u>Table 4</u>.

OD/Weight/	Minimum Safety Factor (Abs)			
Grade	Ni	Nc	Nj	Triaxial
Casing 30", 157,5 ppf, X-52	1,26	3,89	3,12	1,59
Casing 20", 94 ppf, K-55	1,32	1,56	3,32	1,65
Casing 13 3/8", 54,5 ppf, K-55	1,63	1,7	2,83	1,72
Casing 9 5/8", 40 ppf, K-55	1,84	3,56	2,43	2,12
Casing 7", 23 ppf, K-55	2,69	3,4	2,76	2,45

 Table 4. General Summary: Drilling Software

This research aims to enhance the accuracy of drilling casing design planning by utilising drilling software, which typically relies on manual calculations. By doing so, it seeks to obtain more efficient, accurate, and safe results in drilling casing planning. Therefore, theoretically, casing design planning in Well "X-01" using Drilling Software can be used to determine the casing grade, as this method can withstand burst, collapse, and tension loads. This method is also capable of handling drilling problems, specifically the maximum burst load that occurs when the well kicks and the maximum collapse load that arises from lost circulation. Based on the safety factor, each route has met API standards for the durability of the selected casing. This research concludes that drilling casing design planning using Drilling Software can serve as a reference in the stages of the casing design process, as accurate and safe results are obtained.

IV. CONCLUSION

Based on the results of Drilling Casing Design Planning Using Drilling Software at Well "X-01" Field "S" it can be concluded that at Well "X-01" it is planned to use 5 (five) design routes, which is conductor casing route (0 - 164 ft), surface casing route (0 - 1476 ft), intermediate casing (0 - 4373 ft), production casing (0 - 4829 ft), and production liner (0 - 5638 ft).

Based on the Drilling Software, the conductor casing uses X-52 casing; 157.5 ppf non-API welded joint type, the surface casing uses K-55 casing; 94 ppf, the intermediate casing uses K-55 casing; 54.5 ppf, the production casing uses K-55 casing; 40 ppf, and the production liner uses K-55 casing; 23 ppf.

Based on Drilling Software, the safety factor of each route has met API standards for the durability of the selected casing.

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Drilling casing design planning using Drilling Software can serve as a reference in the casing design process stages, as accurate and safe results are obtained.

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