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

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***Abstract:** Well "X-01" is a slant (J-Type) directional well and will be subjected to appropriate and technically qualified drilling casing planning in order 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 document study and quantitative analysis in casing planning using Drilling Software by taking into account the loading acting on the casing, which is burst, collapse, tension, biaxial, and triaxial loads. Casing design planning for Well "X-01" is carried out by analyzing 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 be a reference in the casing design process stage because optimal and safe results are obtained*

***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 with the aim of preventing 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 target of achieving the largest safety factor number, so as to obtain the strongest and safest casing set (Noviandy, 2015, [2]). Casing planning for Well "X-01" was carried out by considering the statigraphic layer, fluid type, and formation pressure.

In this research, " Drilling Casing Design Using Drilling Software at Well "X-01" Field "S"" consisting of 5 (five) drilling routes has been carried out. The kick problem is a requirement for the calculation of kick tolerance with the aim of optimizing 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 existence of this research is expected to be an alternative casing design planning to obtain efficient, accurate, and safe results in the implementation of further drilling in the field.

II. MATERIAL AND METODOLOGY

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

The next methodology is a document study by summarizing documents based on the results of participant observations in the form of Drilling Programs, then manual calculations using excel to determine the depth of casing setting based on mud window analysis and kick tolerance.

The final methodology is casing planning using Drilling Software to design a suitable and technically safe casing, taking into account the loads affecting the casing. The flow chart of Well "X-01" can be seen in Figure 1.

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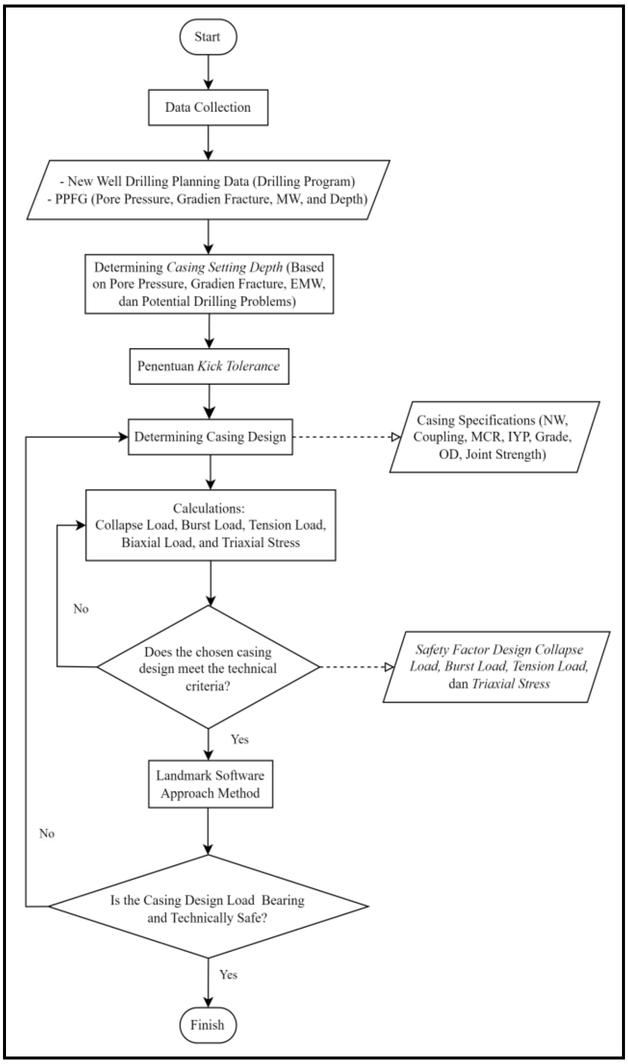

Fig. 1. Flow Chart of Well "X-01" Field "S"

III. RESULT 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 plan 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 Figure 2.

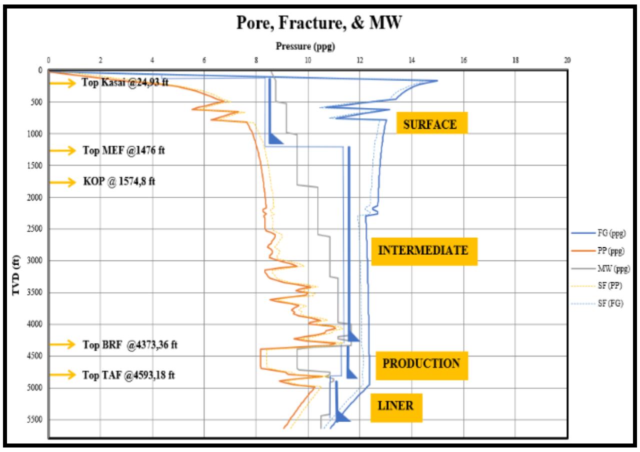

Fig. 2. Casing Planning Setting Depth Well "X-01"

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 inches 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 the final depth of casing at 1473.09 ft had shale lithology as the casing shoe seat.

c. Intermediate *Casing*

In the intermediate casing, a 17 ½ 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.

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 ½ inches, and a casing diameter size of 7 inches.

D. Hole Geometry Determination

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

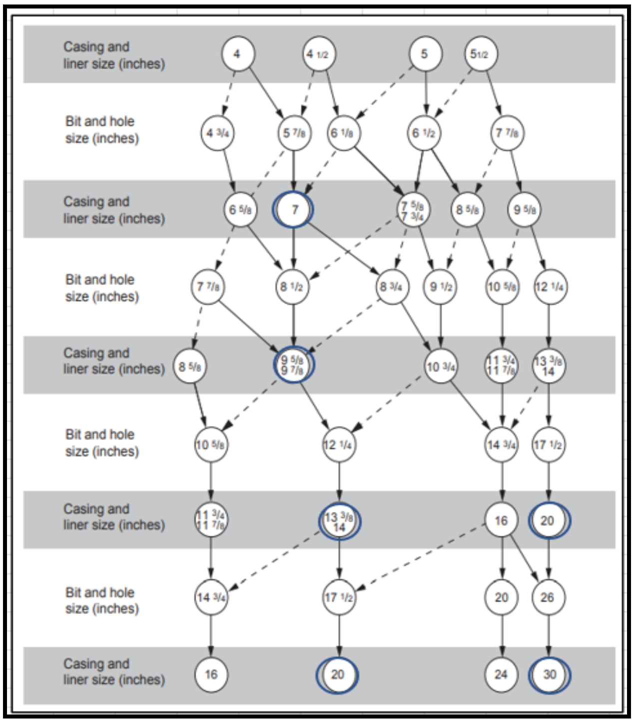

Fig. 3. Bit Size and Casing Selection
(Source: Watt, 2017, [8])

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 ½ inches, 12 ¼ inches, and 8 ½ 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 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 x LOTdepth 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 Table 1.

Table 1. Summary Kick Tolerance Result of Well "X-01" in Drilling Software

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 determining 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. So that the results are obtained as 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 can be seen in Table 3.

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

No.	OD (in)	Name	Hole Size (in)	Measured Depths (ft) Hanger	Shoe	TOC	Mud at Shoe (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

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.

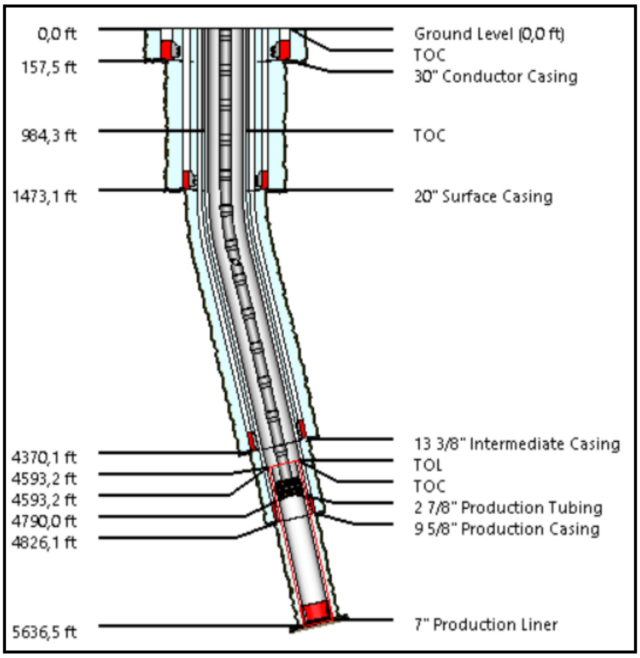

Fig. 4. Planning Hole Geometry of Well "X-01" Field "S"

There are loads acting on the casing according to the API safety factor, namely 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 changed following 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 results from each casing route can be said to be safe because they are above the API SF number. The results of the analysis of each route can be summarized based on Table 4.

Table 4. General Summary Drilling Software

OD/Weight/ *Grade*	Minimum *Safety Factor (Abs)* 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

In this research, drilling casing design planning using Drilling Software aims to improve the accuracy of casing planning which is usually done by manual calculation, so that more efficient, accurate, and safe results are obtained in drilling casing planning. Therefore, theoretically, casing design planning in Well "X-01" using Drilling Software can be used in determining casing grade, because this method is able to withstand burst, collapse, and tension loads. This method is also able to handle drilling problems, namely the maximum burst load when the well kicks and the maximum collapse load when the well experiences lost circulation. Based on the safety factor, each route has met API standards for the durability of the selected casing. So the final conclusion of this research is that drilling casing design planning using Drilling Software can be a reference in the stages of the casing design process because 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, So drilling casing design planning using Drilling Software can be a reference in the casing design process stages because accurate and safe results are obtained.

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Authors Contributions	NS contributed to the read, made suggestions to the manuscript, and approved the submitted manuscript. SWH conceived the study, analysis of the data, and the drafted the manuscript. ES collection and analysis of the data, made suggestions and finalization of the article.

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