Timor-Leste Journal of Engineering and Scince

Vol.1, Issue.1, pp.36-41, 2020
Available online at: https://tljbm.org/jurnal/index.php/tljbm

Casing Setting Depth using Bottom-Up Method for Development Well in the Offshore

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ABSTRACT

Casing setting depth in drilling activities on onshore or offshore is an important aspect that must be planned. The selection of casing setting depths is based on the pore pressure and fracture pressure for the well and is usually available from offset well data. The method used in determining the casing depth is the top-down method and the bottom-up method. Generally, the top-down method is used in exploration drilling and the bottom-up method in development drilling. In certain cases, development drilling also uses the top-down method when complex formation conditions and abnormal pressure are encountered.Furak well is a development well with a depth of 442 ft of seawater and the distance from the rotary table to the seabed is 508 ft, including the category of deepwater wells. Based on the results of the pore-pressure and fracture gradient analysis and the determination of the casing setting depth using the bottom-up method, the results are obtained for the depth of each casing. Zero-point (0) to be calculated from the rotary table (RT). The depth of the conductor casing is 1010 ft with an equivalent mud weight of 8.5 ppg, the depth of the casing surface is 2495 ft with an equivalent mud density of 9.4 ppg, the depth of the intermediate casing is 6470 ft with an equivalent mud density of 10 ppg and a depth of production casing is 9810 ft with an equivalent mud density of 11.3 ppg.

Keywords: pore pressure, fracture gradient, mud density, casing setting depth, top-down method, bottom-up method, onshore, offshore, offset well, equivalent mud density.

1. Introduction

Casing setting depth in drilling activities on onshore or offshore is an important aspect that must be planned. The selection of casing setting depths is based on the pore pressure and fracture pressure gradients for the well and is usually available from offset well data. Drilling problems will arise if the estimated pressure is not properly evaluated, drilling problems that arise such as lost circulation, hole instability, and excessive costs and other problems.

Factors that determine the depth of the casing seat include pore pressure, fracture gradient and other factors are the existing lithologies of rocks. After determining the casing seat can be continued with an analysis of the determination of the appropriate drilling mud (Aadnoy, et al 1989). After the analysis of pore pressure and fracture gradient is carried out, followed by determining the depth of the casing to the total depth. Determination of the casing point from the bottom of the well to the surface based on pore pressure analysis and fracture pressure is called the bottom-up design and vice versa the determination of the casing point from the surface to the bottom of the well based on pore pressure analysis and fracture pressure is called the top-down method. Supporting data that is often used include seismic 3 -D data, and seal quality analysis. Pore pressure analysis and correct pre-drill gradient fracture will reduce the risk and cost of deepwater drilling (Hosalek, et.al., 2006). Technical challenges often encountered in offshore drilling include seafloor slope, and soft seabed conditions, or shallow geohazard risks like shallow water flow (SWF) and hydrate (Syazwan, et. al., 2016).

2. Literature Review

2.1 Deepwater Drilling

In the oil and gas industry, the drilling in offshore has long been carried out but there is nothing clear about the depth for the category of deep water and ultradeep water. There is a difference in depth between deep-water and ultra-deep-water depending on the operator drilling. Blow out preventer (BOP) is designed on the seabed, for deep-water drilling and ultra-deepwater drilling. The America Petroleum Institute (API) defines a water depth of more than 500 ft including the deep-water category, and the International Association Drilling Contractor (IADC) defines a water depth of 2000 ft including the deep-water category and if the depth of more than 2000 ft is included in the ultra-deep-water drilling category (Syazwan, et. al., 2016).

2.2 Subsurface Pressure

Formation pressure can be a major factor influencing a drilling operation. Drilling problems will arise if the estimated pressure is not properly evaluated, drilling problems that arise such as loss of circulation, bursts, pipe jams, hole instability, and excessive costs and other problems (Adams., 1985).

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a) Hydrostatic Pressure

Hydrostatic pressure is the pressure caused by the weight of the fluid column in the formation (Boniface et al., 2015).

$$HP = g \times \rho f \times D \quad (2.1)$$

Where:
HP = hydrostatic pressure (psi)
g = gravitational acceleration
ρf = average fluid density
D = true vertical depth or height of the column (ft)

b) Overburden Pressure.

Overburden pressure is a combination of the weight of the matrix formation (rock) and fluid (water, oil, and gas) contained in the formation (Li et al.,2012).

$$\sigma ov = 0.052 \times \rho b \times D \quad (2.2)$$

Where
σov = overburden pressure (psi)
ρb = formation bulk density (ppg)
D = true vertical depth (ft)

c) Pore Pressure

Pore pressure is the pressure of the fluid in the rock pore space. The pore pressure can be divided into three of them. Normal pressure is the rock pore pressure equal to hydrostatic pressure, abnormal and subnormal pressure is a pressure that is different from the normal trend set for a certain area and depth. Abnormal pressure for pressure higher than normal pressure and subnormal pressure for pressure lower than normal pressure. Abnormal and subnormal pressures are influenced by geological factors and tectonic factors (Anderson et al., 1973).

d) Fracture Gradient

Fracture gradients (FG) are the maximum pressure that can be held by a formation without causing a break in the formation. The magnitude of the fracture formation pressure is influenced by overburden pressure, formation pressure, and rock strength. The method used to determine the formation fracture gradient is formation integrity test (FIT) and leak off test (LOT). The working principle of FIT and LOT is to put pressure on the pumping mud gradually into the well until it sees a sign of formation starting to break from the pressure increase and a sudden drop in pressure. The FIT is carried out on development wells and LOT is carried out on exploration wells. FIT and LOT are done under casing shoes (Zhang et al., 2017).

Calculate the FG using the following formula:

$$FG = \rho_{mud} + \frac{FIT\ (pressure)}{0.052\ x\ D} \quad (2.3)$$

Where:
FG = Fracture gradient (ppg)
ρm = Mud density (ppg)
FIT = Maximum test pressure (psi) after rock fracture
D = TVD (feet)

2.3 Types Casing

The casing is a steel pipe designed with special specifications for oil and gas wells. The type of the casing used include conductor casing, surface casing, intermediate casing, production casing linear casing and each type of casing has a different function (Fertl., 1975).

a) Conductor casing
Conductor casing is the first casing to be lowered in drilling operations by pounding or drilling depending on the formation penetrated. The function of the casing conductor is to hold the formation that easily collapses (Bourgoyne., 1986).

b) Surface casing
Surface casing is installed after casing conductor. The function protects the freshwater layer and as a holder for wellhead and BOP equipment (Moore., 1986).

c) Intermediate casing

The casing intermediate is installed after the surface casing, mounted on a productive formation called open hole completion and installed to the bottom of the productive formation called perforated casing completion. The function isolates the formation casing and production troublesome formation casing setting depth (Rabia., 2002).

d) Production casing

The production casing is lowered after an intermediate casing. The main purpose of this casing is to isolate the production interval from other formations (eg water-bearing sand) and/or act as channels for production tubing (Heriot - Watt., 2005).

2.4 Casing Setting Depth

Casing setting depth is the determination of the seat section casing based on pore pressure data and fractures gradient from offset well. In Figure 2.1 an example of determining the casing of the seat section is explained which has not added a safety factor value (BG Group., 2001).

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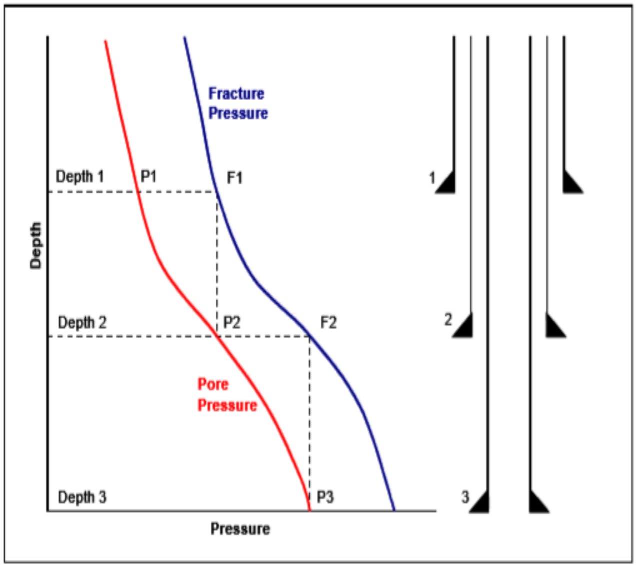

Figure 2. 1 Example of Idealized Casing Seat Selection (BG Group., 2001)

a) Conductor Setting Depth

Conductor casing is the first casing to be lowered during drilling operations. Determination of conductor setting depth based on fracture gradient and effective mud weight and if the determination of the depth setting conductor is not correct it will cause drilling problems such as kick or loss. The conductor casing used must be able to withstand heavy circulation of mud weight for the next section, holding wellhead loads, BOPs and additional casing loads (BG Group., 2001).

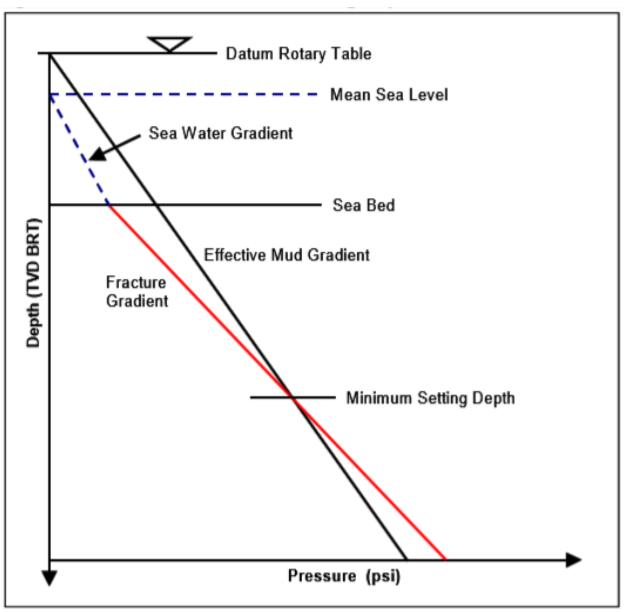

Figure 2.2 Conductor minimum setting depth (BG Group., 2001).

b) Surface, Intermediate and Production Casing

The casing function for onshore and offshore drilling is almost the same. In offshore drilling determination of casing setting depth for surface, intermediate and production casing based on several parameters such as water depth, and type of kick (kick volume and depth kick below seafloor), original mud density, hole size, drill pipe size, kill mud density for determining formation pressure and fracture gradient (Schub., 1979).

2.5 Casing Setting Depth (CSD) used Top-Down Method and Bottom-Up Method

Top–down well design is well design begins with the selection of the conductor depth, once this depth has been selected, next determines subsequent casing point base on pore pressure and fracture gradient data. Bottom–up well design is establishing the desired casing size at total depth for drilling wells, for the most part, determines the casing point from total depth to the surface (Hosalek, et.al., 2006)

3. Methodology

3.1 Data Collection

Data collection is an implementation to obtain the necessary data from various sources in preparing the reseach. Required data include: Furak well is a development well with a depth of 442 ft of seawater and the distance from the rotary table to the seabed is 508 ft, total depth from rotary table 9840 ft and total depth from seabed 9332 ft Based on lithology of rock types found in well formation lithology is dominated by calciliutite and lime stone, for the final drilling target at a depth with sandstone rock. The offset well shows a normal pressure regime down to total depth, the predicted pore pressure and fracture gradient plot has been revised to accommodate the estimate pore pressure of not be problem in well development.

3.2 Diagram Reseach

The methodology used for this research as follows:
a) Pre-evaluation
Data collection: the data used consist of primary data and secondary data related to the topic under study.
Field observation: observations were made to determine the condition of the field and observe matters relating to deep sea drilling operations.

b) Evaluation
Data analysis: data that have been processed, then analyzed so that will get the results in accordance with the purpose of research.
Literature study: literature study was conducted to obtain library materials in the form of theories and formulations that

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can support the research activities. The literature materials can be obtained from related institutions, libraries, published scientific reports, other information, and previous research reports on the same topic.

c) Planning
Data processing: data processing is done based on the results obtained from observations in the field which then processed based on the literature associated with the object under study.

d) Execution
Based on existing data and analysis, we can design a casing setting depth that suits the needs and standards that apply in the industry (Marbun., et. al, 2015).

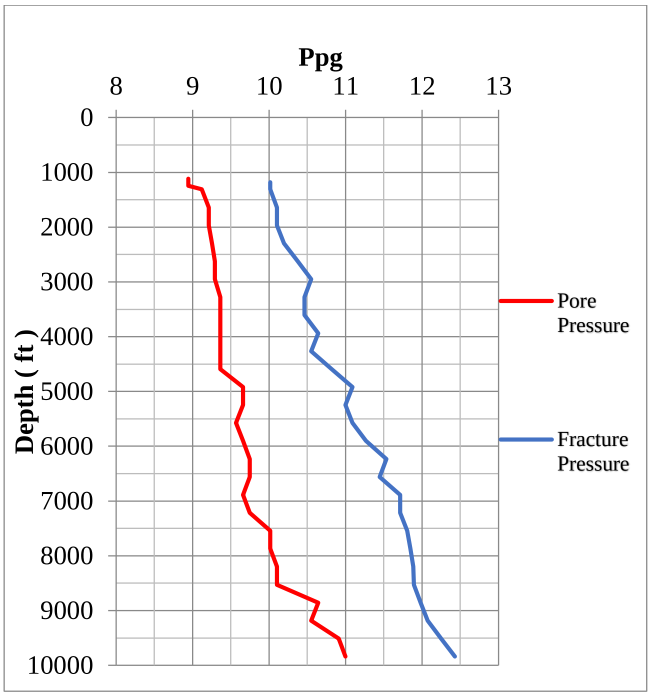

Figure 2.3 Profile Pore Pressure and Fracture Pressure (Offset well data).

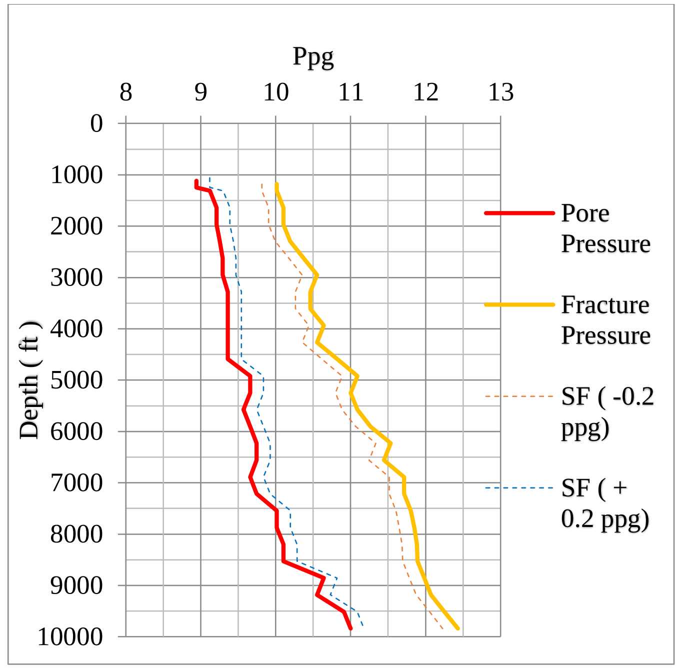

Figure 2.4 Safety margin 0.2 ppg for pore pressure and fracture pressure.

4. Result and Discussion

4.1 Safety Margin

The solid lines in the chart are not accounted for safety factor; therefore, for the first step of casing seat design, safety margin must be applied, the recommended test margin for development well is 0.2 ppg (0.02 sg) and for exploration/appraisal wells 0.5 ppg (0.06 sg). In this study, a safety margin of 0.2 ppg was used. The safety margin will be added to 0.2 ppg in pore pressure and a decrease of 0.2 ppg in the gradient fracture (Figure 2.4). The goal is to prevent drilling problems when circulating the drilling mud.

4.2 Bottom–Up Method

This design will start from the bottom of the well up to conductor setting depth and the setting depths are designed within the safety factor limits (dotted lines). Starting at the bottom at depth 9840 ft, draw a vertical line upward to fracture pressure dashed at depth 6470 ft. The casing should be set from 6470 ft TVD to 9840 ft and long stretch drilling for this section 3370 ft TVD. This section is part of the production casing.

The next casing string is starting at the bottom at depth 6470 ft, draw a vertical line upward to fracture pressure dashed at depth 2495 ft. The casing should be set from 2495 ft TVD to 6470 ft and long stretch drilling for this section 3975 ft TVD. This section is part of the intermediate casing. The next casing string is starting at the bottom at depth 2495 ft, draw a vertical line upward to fracture pressure dashed at depth 1010 ft. The casing should be set from 1010 ft TVD to 2495 ft and long stretch drilling for this section 1485 ft TVD. This section is part of the surface casing.

The next casing string is starting at the bottom at depth 1010 ft, draw a vertical line upward to fracture pressure dashed at depth 508 ft. The casing should be set from 508 ft TVD to 1010 ft and long stretch drilling for this section 502 ft TVD.

This section is part of the conductor casing. The well depth of 508 ft as the starting point for the conductor casing is calculated from the rotary table, when calculated from the sea bed the depth of 508 ft is the same as the depth for 0 ft

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(figure 2.5). It can be seen the difference for the casing setting depth onshore and offshore.

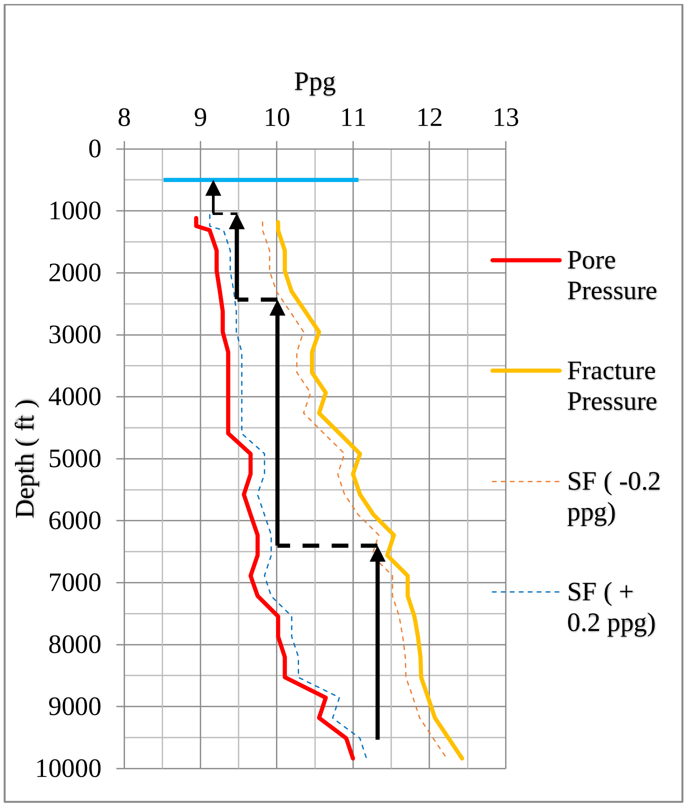

Figure 2.5 Casing setting depth Furak well

4.3 Hole Geometry Plan and Mud Plan

After the casing setting depth is determined, the next step is to determine the hole geometry and the mud weight equivalent. Conductor casing section with a depth of 502 ft, hole / bit diameter 30", casing diameter 24" and an equivalent mud weight plan of 8.5 ppg.

Table 2.1 Equivalent Mud Density Plan

Well	Casing Setting Depth (ft) from Rotary Table	Tipe Casing	Equivalent Mud Density (ppg)
Furak	1010	Conductor	8.5
	2495	Surface	9.4
	6470	Intermediate	10
	9840	Production	11.3

Surface casing section with a depth of 1987 ft, hole / bit diameter 20", casing diameter 16" and an equivalent mud weight plan of 9.4 ppg. Intermediate casing section with a depth of 5962 ft, hole / bit diameter 14.75", casing diameter 10.75" and an equivalent mud weight plan of 10 ppg. Production casing section with a depth of 9332 ft, hole / bit diameter 8.75", casing diameter 7" and an equivalent mud weight plan of 11.3 ppg.

Table 2.2 Hole Geometry Plan

Well	Casing Setting Depth (ft) from Rotary Table	Tipe Casing	Hole Geometry Plan	
			Hole Size (in)	Casing Size (in)
Furak	1010	Conductor	30	24
	2595	Surface	20	16
	6470	Intermediate	14.75	10.75
	9840	Production	8.75	7

The Table 2.2 describes the length of the track, mud density plan, and the hole geometry plan for each section of the case in designing a well program used bottom–up well design

4.3 Result Casing Setting Depth Design Furak Well

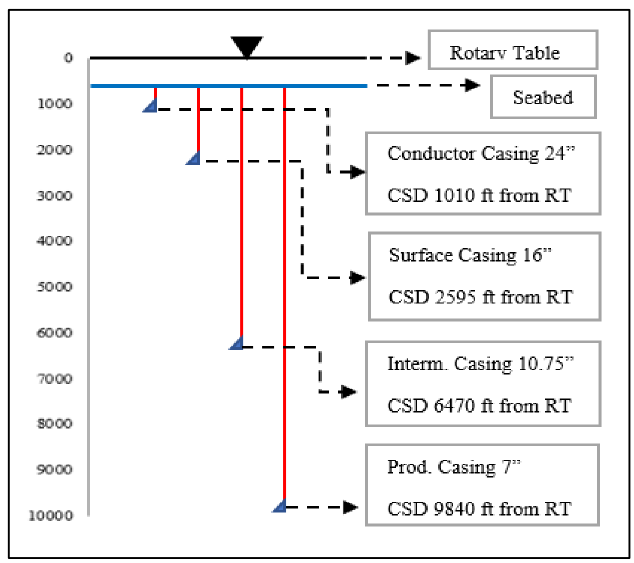

Figure 2.5 Casing Setting Depth design Furak well

Based on the results of pore pressure and fracture pressure analysis on furak well, the results of the casing setting depth design, equivalent mud weight, hole geometry and casing size (Table 2.1, Table 2.2, and Figure 2.5) can be used in well plans for Furak well drilling.

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5. Conclusion and Suggestions

5.1 Conclusion

a) Furak well is a vertical well drilling offshore with deepwater drilling category with a depth of 508 ft from rotary table (RT) to the bottom of the sea and the actual sea depth is 442 ft. Zero-point (0) to be calculated from the rotary table (RT).
b) Casing setting depth for conductor casing at a depth of 1010 ft with a planned 8.5 ppg equivalent mud density, hole size 30” and casing size 24”
c) Casing setting depth for surface casing at a depth of 2595 ft with a plan of 9.4 ppg mud density, hole size 20” and casing size 16”
d) Casing setting depth for intermediate casing at a depth of 6470 ft with a plan of 10 ppg equivalent mud density, hole and bit size 20” and casing size 16”
e) Casing setting depth for production casing at a depth of 9840 ft with a plan of 11.3 ppg equivalent mud density, hole size 20” and casing size 16”

5.2 Suggestions

The top-down method is generally used for exploration drilling and the bottom-up method is generally used for development drilling, however, not all development wells use the bottom-up method, it can be used the top-down method for complex subsurface geological conditions.

References

Aadnoy, B. S., Soteland, T., Rogeland, U., Ellingsen, B., (1989): Casing Point Selection at Shallow Depth, Drilling Conference, SPE/ IADC 18718, 825 – 836.

Adams, N. J., (1985): Drilling Engineering a Complete Well Planning Approach, Tulsa, Oklahoma: Penn Well Books.

Alliquander, O., (1974): Design Method of Setting Depth of Protecting Casing String in Hungary, SPE- European Spring Meeting, SPE-4832.

Anderson, R. A., Ingram, D. S., and Zanier, A. M., (1973): Determining Fracture Pressure Gradients from Well Logs, Journal of Petroleum Technology.

Bourgoyne, J., Adam, T., Millheim, K. K., Chenevert, M. E., Jr Young, F. S., (1986), *Applied Drilling Engineering*, Society of Petroleum Engineers, Richardson TX, United State of America.

Boniface, O. A., Marcus, N. M., (2015): A Model to Determine the Effect of Pore Pressure and Fracture Gradient on Stuck Pipe Management, Nigeria Annual International Conferences and Exhibition held in Lagos, SPE 178379 MS

BG, Group., (2001): Well Engineering and Production Operations Management System, Casing Design Manual, 30 – 35

Fertl, W. H., (1975): Abnormal Formation Presure, Implication to Exploration, Drilling and Production of Oil and Gas Resourch, Ponca City Oklohama.

Lage, A. C. F. M, Edson Y., Nakagawa., Rocha L. A. S., (1997): Description and Application of New Criteria for Casing Setting Depth, Offshore Techology Conference, OTC 8464.

Holasek, F. R., Singh, R. K., Shanker, S., (2006): Determination of 20 – in. Conductor Setting Depth in Deepwater Wells in the Krishna – Godavari Basin Offshore India, Drilling Technology Conference and Exhibition, SPE/IADC – 103667, 1 – 8.

Heriot–Watt., (2005): Drilling Engineering.

Kotow, K. J., and Pritchard, D. M., (2008): Exploting Shallow Formation Strengths to Deepen Riserless Casing Seat, SPE Annual Technical Conferences and Exhibition held in Dallas, SPE 191724 MS.

Li, S., Purdy, C., Wu, S., (2012): Pore Pressure and Fracture Gradient Prediction in Shale Gas Formation: Accounting for Complex Rock Properties an Anisotropies, IADC/SPE Asia Pasific Drilling Technology Conferences and Exhibition held in Tiajin, IADC/SPE 155540.

Marbun, B., Purba N. P., Fadholi, B. Z., (2015): An Integrated Management of Drilling Design and Operational of Geothermal Well, Proceedings World Geothermal Congress, 1 – 10.

Moore, P. L., (1986): Drilling Practices Manual, Second Edition, Penn well books, Tulsa Oklahoma USA.

Rabia, H., (2002): Well Engineering and Construction.

Santos, O., Adasani, I., Azar, J. J., Escorihuela, F., (1995): Determination of Casing Setting Depth Using Kick Tolerance Concept, Petroleum Computer Conferece, SPE – 30220

Schub, F. J., (1979): Conductor and Surface Casing Depth Requirement for Deep Water, Annual Fall Techology Conference and Exhibition, SPE-8316.

Syazwan, M., Shafei, A., Paimin, M. R., Su’if, M. Z., Abidin, H. Z., Ismail, Y., Natarajan, S., (2016) Enhancement of Structural Conductor Design and Execution of Jetting Operation for Ultra-Deepwater Wells in Brunei, Asia Pasific Oil and Gas Conference and Exibition, SPE – 182427 – MS, 1 – 17.

Zhang, J., and Yin, S.X., (2017) : Fracture Gradient Prediction: An Overview and Improved Method, Pet. Sci.
DOI 10.1007/s12182-017-0182-1