Journal of Science, Technology, and Visual Culture
Vol. 3, No. 2, 2023
e-ISSN 2798-8767
p-ISSN 2807-7997
homepage: journal.itera.ac.id/index.php/jstvc

# Effectiveness of Directed Drilling Track Planning Method with Variation of Build Up Rate

Stevy C Louhenapessy[1*], Randa P J Melato[2]

[1] Department of Oil and Gas Engineering, Faculty of Production and Industrial Technology, Sumatera Institute of Technology, Jl. Terusan Ryacudu, Lampung, Indonesia - 35365

[2] Department of Petroleum Engineering, Faculty of Mining and Petoleum, University of Papua, Jl. Gunung Salju Amban, Manokwari, West Papua, Indonesia - 98314

* Corresponding email: stevy.louhenapessy@rmg.itera.ac.id

**Riwayat Artikel**
Diterima
05/08/2022
Disetujui
03/10/2022
Diterbitkan
31/07/2023

**Abstrak**

Pengujian build-up rate pada studi kasus ini dilakukan dengan menggunakan tiga variabel *Buil Up Rate (BUR)* yaitu 3°/100 ft, 5°/100 ft, and 7°/100 ft yang disimulasikan menggunakan metode *directional drilling trajectory*. Hasil masing-masing *BUR* yang diperoleh dengan menggunakan metode lintasan pemboran build and hold menghasilkan sudut inklinasi maksimum sebesar 39,197°, 31.854°, dan 30.093°; kedalaman vertikal hingga akhir pembuatan sudut adalah 1707,02 ft, 1104,77 ft, dan 910,41 ft; kedalaman terukur hingga akhir pembuatan sudut adalah 1807 ft, 1137 ft, dan 930 ft; dan kedalaman terukur hingga ke titik target adalah 2584 ft, 2556 ft, dan 2547 ft. Sedangkan hasil dari masing-masing *BUR* yang diperoleh dengan menggunakan metode *buildup drilling trajectory* menghasilkan sudut inklinasi maksimum sebesar 56,68°, 76,289°, dan 95.562°; kedalaman penampang vertikal hingga akhir bangunan sebesar 2269,92 ft, 2298,22 ft, dan 2311,95 ft; kedalaman terukur hingga akhir pembangunan sudut 2563 ft, 2711 ft, dan 2886 ft; dan kedalaman terukur ke titik target adalah 2636 ft, 2759 ft dan 2886 ft. Perbandingan BUR yang dilakukan pada kedua metode ini memiliki kelebihan dan kekurangan dari segi parameter yang dianalisis. Parameter ini dapat mempengaruhi risiko pengeboran, efisiensi waktu pengeboran, dan ekonomi.

**Kata Kunci**: *Build Up Rate*, Pemboran Berarah, *Bottom Hole Assemblies*, *positive displacement motor, Weight on Bit*

**Abstract**

The build-up rate test in this case study was carried out using three BUR variables, namely 3°/100 ft, 5°/100 ft, and 7°/100 ft, which were simulated using the directional drilling trajectory method. The results of each BUR obtained when using the build and hold drilling trajectory method resulted in a maximum inclination angle of 39,197°, 31.854°, and 30.093°; the vertical section depth to the end of the build were 1707.02 ft, 1104.77 ft and 910.41 ft; the measured depths to the end of the build were 1807 ft, 1137 ft, and 930 ft; and the measured depths to the target point were 2584 ft, 2556 ft, and 2547 ft. While the results of each BUR obtained when using the buildup drilling trajectory method resulted in a maximum inclination angle of 56,68°, 76,289° and 95.562°; the vertical section depth to the end of the build of 2269.92 ft, 2298.22 ft and 2311.95 ft; measured depths to the end of the build of 2563 ft, 2711 ft and 2886 ft; and the measured depth to the target point were 2636 ft, 2759 ft and 2886 ft. BUR comparisons performed on these two methods have advantages and disadvantages in terms of the analyzed parameters. This parameter can affect drilling risk, drilling time efficiency, and economy.

**Keywords**: Build Up Rate, Directional Drilling, Measured Depth, Bottom Hole Assemblies, positive displacement motor, Weight on Bit

## 1. Introduction

Directional drilling is a drilling technique that involves turning a wellbore and then directing it to a specific target in a formation that is not vertically below the well's mouth. The right method will lead to the right drilling, which will necessitate more detailed calculations and considerations in order to achieve an effective trajectory method. The inclination angle, vertical depth to the end of the angle, measured depth to the end of the angle, and measured depth to the target point are all parameters to consider. The goals and objectives of this study are to determine the effectiveness of the build-up rate on directional drilling trajectories using the build and hold method, as well as which type of directional drilling is more effective. and the method of build-up. For directional wells in particular, planning is critical to lowering and controlling overall costs. The planning process starts with choosing one of the wellbore patterns (profiles) shown in Figure 1. Build and hold is a common description for these profiles. Continuously build, hold, and drop (S shape). [1] .

1. Continuous build type, In this type of drilling, the angle formation after the kickof point continues until it reaches the target. [2]
2. Build and hold type, In this type of drilling, after the inflection point, drilling is carried out in two forms, namely the first path to build the angle to the angle we want (build section), and the second path of drilling is carried out by maintaining the angle that has been achieved to the target (hold section). [2]
3. Build-hold and drop (S type), In this type of drilling, after the inflection point, the well trajectory is the same as the build and maintain angle type, but at a certain distance from the straight section (hold section), the well trajectory is returned to the vertical direction [2].

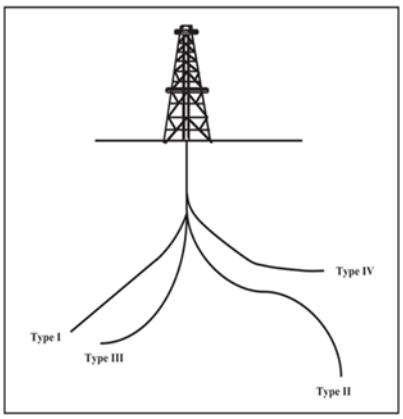


Figure 1. Wellbore Patterns [1]

The build and hold type requires the smallest inclination angle for the same goal, while the S type requires a larger inclination angle than the build and hold type and the continuous build type requires the largest inclination angle. [3]. The location of the coordinates on the surface and the distance between the surface and the target, the location of the inflection point, the number and location of the targets to be achieved, and the ease of implementation are all factors in deciding which type of directional drilling to use. The wellbore's trajectory to reach the target is the first step in planning a directional well. The following are the steps in planning the trajectory:

1. Determine the depth of the target, the number of targets, and the horizontal distance of the target using geological data.
2. Determine the best starting point and rate of increase (BUR).
3. Choose the right path type (continuous build, build and hold, or build-hold-drop/S).
4. Making horizontal and vertical trajectory projections [3].

### *Build and Hold Design*

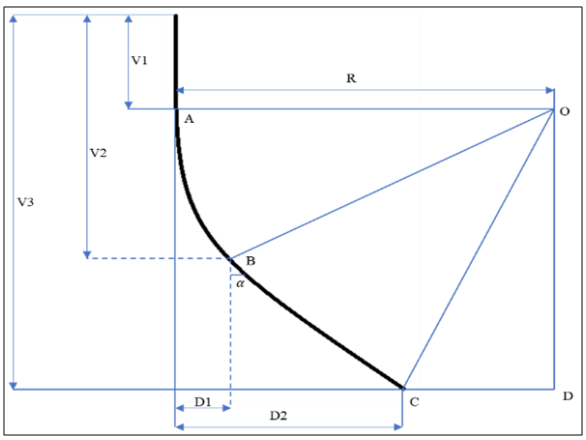


Figure 2. Well Profile Build and hold section [4]

The maximum inclination angle $\alpha_{max}$r type build and hold trajectory can be calculated for two cases using the detailed trigonometry shown in Figure 2. This equation use equation from rabia book [4].

First Case R > D2

For type build and hold trajectory, the maximum inclination angle $\boldsymbol{\alpha_{max}}$ given by:

$$\alpha_{max} = \arctan\left[\frac{(V_3-V_1)}{(R-D_2)}\right] - \arctan\left(\left(\frac{R}{V_3-V_1}\right) \times \sin\left[\arctan\left(\frac{V_3-V_1}{R-D_2}\right)\right]\right) \quad (1)$$

Second Case R < D2

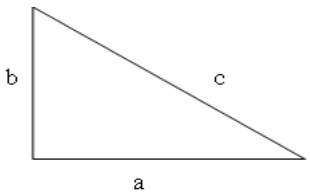
$$\alpha_{max} = 180 - \arctan\left[\frac{(V_3-V_1)}{(D_2-R)}\right] - \arccos\left(\left(\frac{R}{V_3-V_1}\right) \times \sin\left[\arctan\left(\frac{V_3-V_1}{D_2-R}\right)\right]\right) \quad (2)$$

### *Build Up Section*

1. Radius of curvature ® of buildup Section

$$R = \frac{360\times100}{2\times\pi\times BUR},\ Where\ BUR = \frac{degrees}{100}ft \quad (3)$$

2. If the kick of point value is not known, then interpolation using known data is used. The equation is as follows:[2]




a = the distance to be sought to determine the KOP point

b = interval between radius and Vertical Section

c = radius

determine the angle α,

$$\sin\alpha = \frac{b}{c}$$

$$\alpha = \arcsin\frac{b}{c}$$

After getting the desired angle then the next step is to find the value of a, which is the value to get a new KOP point.

$$\cos\alpha = \frac{a}{c}$$

$$KOP = TVD - a \quad (4)$$

3. Measured length of buildup section

$$MD_2 = \frac{\alpha_1\times100}{BUR} \quad (5)$$

Where $\alpha$ = end of buildup section maximum inclination angle.

4. Build-up section vertical length

$$V_2 - V_1 = R_1 \times \sin\alpha \quad (6)$$

5. At the end of the build-up section, horizontal displacement (departure) occurs

$$D_1 = R_1 \times (1 - \cos\alpha) \quad (7)$$

***Tangent Section***

6. Determine measured length of tangen section used this equation

$$MD_3 = \frac{V_3 - V_2}{\cos\alpha} \quad (8)$$

7. Determine vertical length of tangent section used this equation

$$V_3 - V_2 = MD_3 \times \cos\alpha \quad (9)$$

8. Determine horizontal displacement end of tangent section

$$D_2 = D_1 + MD_3 \times \sin\alpha \quad (10)$$

9. Determine total MD for type build and hold trajectory

$$TMD = MD_1 + MD_2 + MD_3 \quad (11)$$

## 2. Methodology

The research purpose of this study is determining the effectiveness of a directional drilling trajectory by assuming a buildup rate that used two drilling trajectories, the build and hold trajectory and the build up trajectory, with the build up rate is $3^0$/100 ft, $5^0$/100 ft, and $7^0$/100 ft. The data were taken from one of well data from PT. PetroChina International (Bermuda) Ltd.'s the Kasim Marine Terminal, 2011. Furthermore, True Vertical Depth (TVD) data is 2309.67 ft, Build Up Rate is $5^0$/100 ft, Vertical Section is 921.23 ft, Location Coordinates is latitude $1^0$ 26' 32.79 S and longitude $131^0$ 8' 45.48 E or +North/-South is 901.10 ft and +East/-West is -191.54 ft were the data used in this study. The explanation of the data used in directional drilling planning can be seen in tables 1 and 2. Table 1 is the data used for the build and hold method, while Table 2 is used for the build-up method. The second difference lies in the KOP point. In Table 2, the KOP point is initially unknown and calculations are carried out to find the KOP value using Equation 4.

Table 1. The information is utilized to create a build and hold directional drilling trajectory.

| Description | Build-Up Rate (BUR) | | |
|---|---|---|---|
| | Case 1 | Case 2 | Case 3 |
| | $3^0$/100 ft | $5^0$/100 ft | $7^0$/100 ft |
| *Kick Of Point (KOP), ft* | 500 | 500 | 500 |
| *Vertical Section, ft* | 921.23 | 921.23 | 921.23 |
| *True Vertical Depth (TVD), ft* | 2390.67 | 2390.67 | 2390.67 |
| *North, ft* | 901.10 | 901.10 | 901.10 |
| *East, ft* | -191.54 | -191.54 | -191.54 |

Table 2. The information is utilized to create a build-up directional drilling trajectory.

| Description | Build-Up Rate (BUR) | | |
|---|---|---|---|
| | Case 1 | Case 2 | Case 3 |
| | $3^0$/100 ft | $5^0$/100 ft | $7^0$/100 ft |
| Kick Of Point (KOP), ft | 674 | 1184.96 | 1497.29 |
| Vertical Section, ft | 921.23 | 921.23 | 921.23 |
| True Vertical Depth (TVD), ft | 2390.67 | 2390.67 | 2390.67 |
| North, ft | 901.10 | 901.10 | 901.10 |
| East, ft | -191.54 | -191.54 | -191.54 |

The reason for the KOP point in table two is not known based on the real field data used in this paper. This paper uses field data with basic data for the build and hold trajectory method with a BUR of $5^0$/100 ft. and a KOP value of 500 ft. The flow of this research can be seen in Figure 3.

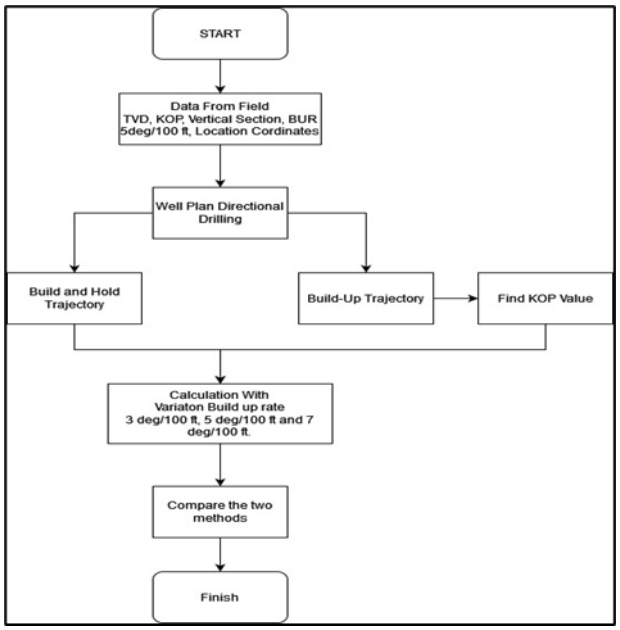


Figure 3. Flow Chart Research

## 3. Result & Discussion

Directional drilling trajectory planning using the Build and Hold method is a type of drilling carried out by forming two paths, namely the first path to build the angle (build section) and the second path to maintain the angle (hold section) to the desired target point. As for the build-up method, drilling is carried out by forming an angle after passing through the kick-off point continuously until it reaches the target point. The two methods will be compared by looking at the parameters in the form of the maximum inclination angle value, the vertical section depth to the end of the build, the measured depth to the end of the build, and the measured depth to the target point. Table 3 shows the values of each calculated parameter for the two methods compared. The pattern of the directional drilling trajectory of the two methods is shown in Figure 5-7, which is compared to each different BUR value.

The comparison parameters for the two methods have different outcomes for each variable, as shown in table 3. The relationship between the BUR value and the tested parameters in the build and hold method is inversely proportional, which means that when the BUR is low, the result value for each parameter is high, and when the BUR is high, the value of the tested parameter is low. The relationship between BUR and the variables analyzed is directly proportional in the Build Up method. When comparing the effectiveness of different methods at various BUR values, it becomes clear that each approach has advantages and disadvantages in terms of the parameters that are used to evaluate the method. Applying those variation of BURs also has impact to the bottom hole assemblies (BHA) especially the positive displacement motor (PDM) used in the project. Figure 4 showing the proportional relationship between the BUR applied to bending stress factor of PDM [5]. As noticed that lower BUR is favorable by having the lower pressure on the surface of PDM to avoid excessive drag force during drilling operation.

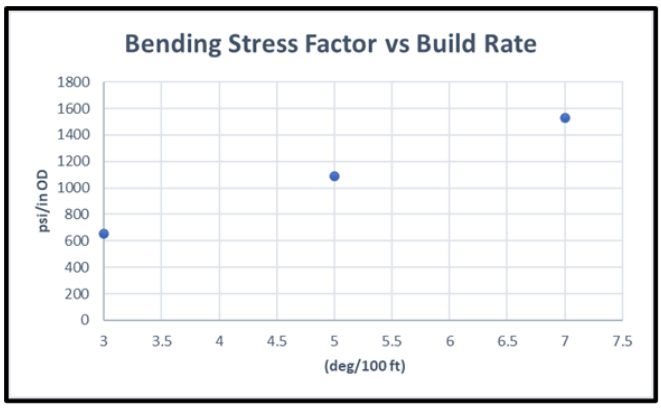


Figure 4. Relationship of Bending Stress and Build Up Rate

Directing trajectory using PDM needs a proper bent sub adjustment before tripped into the hole. The typical bent sub used in the field is surface-adjustable with incremental bending varies from 0 to 3 degrees, the bent housing has a adjustable ring that can be easily adjust using rotary tong on the rig. As can be seen from Table 4 the combination of two stabilizers into the assembly and applying high weight on bit to generate the fulcrum force all along the build is necessary for minimizing the downward movement on the drill string during the building process. It also noticed that the higher the BUR the higher the weight on bit applied to curve the string however it is also detrimental to the string since higher BUR leads to higher drag force to the PDM and higher weight applied aggressively increase torque on the bit. The build and hold trajectory in contrast has shorter arc generated thus it potentially has lower WOB applied in total, minimum drag force and has reasonable torque on bit. However, at the end of the build-up or the starting point of the hold section, the bent sub needs to re-adjust on the surface which significantly time consuming.

The advantages of the Build and Hold method can be seen in the following changes in the values of the tested parameters when employed in

directional drilling trajectory planning: Because the chance of pipe sticking in drilling operations is relatively low, the amount of drill pipe and casing required is relatively low, and the measured depth obtained is relatively short, resulting in a low estimated cost. The weakness of this method is that the effect of the drilling time required is relatively longer, due to the process of stopping the drilling operation to change the drill motor settings to change the point of view of the angle building process (build section) the process of maintaining the desired angle until it reaches the target (hold section).

Table 4. Bottom Hole Assembly

| Equipment | Length (ft) | Number |
|---|---|---|
| PDC Bit | 0.98 | 1 |
| Drilling Motor (stabilizer included) | 27.50 | 1 |
| Float Sub | 2.85 | 1 |
| Stabilizer | 6.63 | 1 |
| NMDC | 30.75 | 1 |
| MWD | 5.54 | 1 |
| HWDP | 278 | 9 |
| Drilling Jar | 32.5 | 1 |
| HWDP | 184.62 | 6 |

During drilling operations, the Build-Up approach has a high risk of pipe sticking. Because the maximum inclination angle produced is relatively high, the required for drill pipe and casing is more than with the Build and Hold method, resulting in higher operating costs. That's because the depth generated is greater than the depth generated by using the same BUR value in the Build and Hold method. Furthermore, the Build-Up method gives advantages that the Build and Hold method does not, such as: the time required for drilling is less than that required for the build and hold method. That's because the Build-Up method drills continuously without making any significant adjustments to the drill string component to reset the drilling operation, because the angle is built continuously until the required drilling target is accomplished. Another advantage of this method is that it can penetrate a thin but wide oil and gas reservoir, such as a lens reservoir, which is desirable to penetrate all at once, and it prevents gas and water coning, resulting in higher fluid production than the build and hold method.

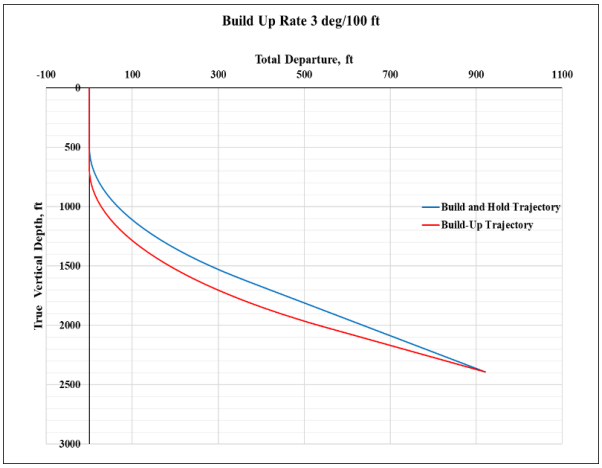



Figure 5. Directional Drilling Trajectory with BUR $3^0$/100 ft

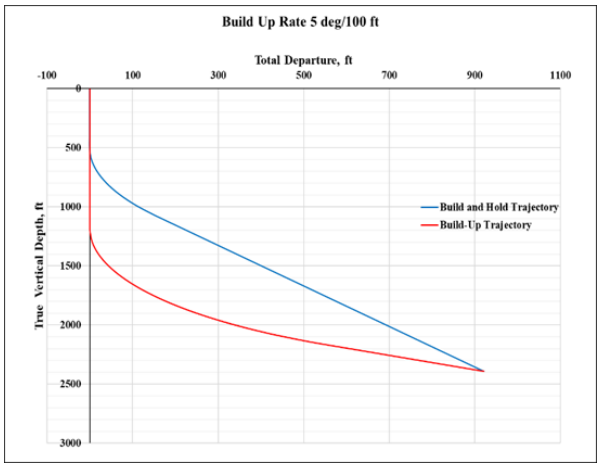



Figure 6. Directional Drilling Trajectory with BUR $5^0$/100 ft

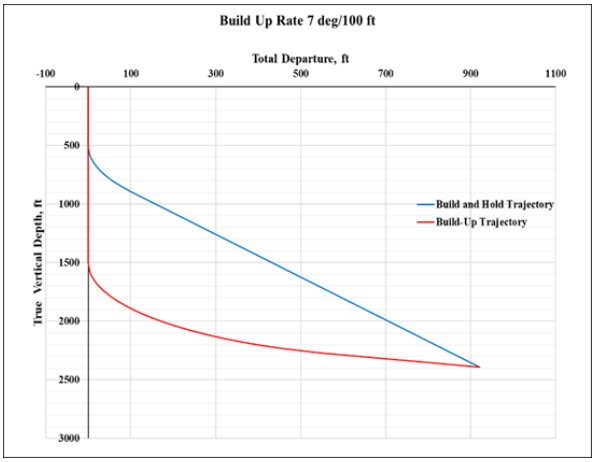



Figure 7. Directional Drilling Trajectory with BUR $7^0$/100 ft

## 4. Conclusion

$3^0$/100 ft of build and hold trajectory seems to has the lowest bending stress working on the motor which leads to the safest drilling process, while the $5^0$/100 ft is the optimum BUR that can be applied. Moreover, the arc of build and hold trajectory is shorter than build up type which needs less WOB in total and requires fewer drill collars or heavy weight drill pipes. This research will be further developed

using drilling software. currently the author only discusses the impacts when the build up rate is increased or decreased from the actual data carried out in the field is $5^0$/100 ft.

**Reference**

[1] J. J. Azar and G. R. Samuel, *Drilling Engineering*. PennWell Corporation, 2007.

[2] A. T. B. Jr, *Applied drilling engineering*, vol. 24, no. 4. 1987. doi: 10.1016/0148-9062(87)90345-7.

[3] Rudi Rubiandini RS, *Buku Teknik Pemboran Volume 1*, vol. 1. 2014.

[4] H. Rabia, "Well Engineering & Construction Hussain Rabia," p. 1 to 789, 2002.

[5] Weatherford, *PrecisionDrill Mud Lubricated Drilling Motors*, First. Canada: Weatherford, 2006.