

# Kick-Off Point (KOP) and End of Buildup (EOB) Data Analysis in Trajectory Design

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## Abstract

Well X is a development well which is directionally drilled. Directional drilling is chosen because the coordinate target of Well X is above the buffer zone. The directional track plan needs accurate survey calculation in order to make the right track for directional drilling. There are many survey calculation in directional drilling such as tangential, underbalance, average angle, radius of curvature, and mercury method. Minimum curvature method is used in this directional track plan calculation. This method is used because it gives less error than other method. Kick-Off Point (KOP) and End of Buildup (EOB) analysis is done at 200 ft, 400 ft, and 600 ft depth to determine the trajectory design and optimal inclination. The hole problem is also determined in this trajectory track design. Optimal trajectory design determined at 200 ft depth because the inclination below 35° and also already reach the target quite well at 1632.28 ft TVD and 408.16 AHD. The optimal inclination at 200 ft KOP depth because the maximum inclination is 18.87° which is below 35°. Hole problem will occur if the trajectory designed at 600 ft. The problems are stuck pipe and the casing or tubing will not able to bend.

**Keywords:** Directional Drilling, Trajectory, Kick of Point, End of Buildup, Minimum of Curvature

## 1. Introduction

Directional drilling is a technique to deflect the wellbore and then directed to desired target in the formation also not located vertically below the well. In the beginning, directional drilling is used to correct the turn that occurred at the vertical hole. (Grace BS, Widrajat, AK, 2015) (Adams, 1985) (Rubiandini, 2012). Actually in drilling always desirable a vertical hole because of The operation cost is cheaper and easier to implement. But not all Drilling can be done vertically certain reasons, so it should be directional drilling. (Grace BS, Widrajat, AK, 2015) There are causative factors in directional drilling: (Bourgoyne, AT, 1991) (Inglis, 2005)

1. Topograph Factor
  - a. Productive formation is located below the lake or river.
  - b. Productive formation is located below the buildings.
2. Geological Factor
  - a. Salt dome
  - b. Faults
3. Economic Factor
  - a. Land acquisition fee
  - b. Equipment removal
  - c. Waste treatment
4. Multi-lateral cluster system
5. Cluster System
6. Blowout prevention by relief well.
7. Sidetracking

There are 3 common types of track in directional drilling: (Rabia, 2002), (Adila, Maruti Tiffani, 2015) (Mitchell, 1995) (Omar Farah, 2013) (Mitchell and Miska, 2011).

- a. Build Hold  
The turning point depth in Kick-Off Point located not too far from the surface (shallow). The deflection of hole is done by increasing the slope and corresponded to Buildup Rate (BUR) that has been planned. Kick of Point (KOP) is the point or depth where the well track will be distorted until it reaches the specified inclination angle. (Hamid and Setiawan, 2015)
- b. Build Hold and Drop  
This type is used in certain condition, for example at salt dome or while sidetracking. The deflection of hole is done far from the surface casing, and the the slope is maintained until reach the target. The well with the deep turning point or Kick-Off Point (KOP) have certain deficiency, there are:
  1. The formation may be harder and is hard to deflect.
  2. Tripping will be more often to replace Bottom Hole Assembly (BHA) while turning.
  3. Buildup Rate will be uncontrollable.
- c. Build Hold Partial Drop and Hold  
First, it will be same with the deflection in the shallow depth but then it will be deflected

again into vertical. As for the selection for the type of drilling based on coordinate between surface location and the target location or the desired formation.

After the plan and the drilling operation is done, the measurement of slope for each depth and the direction of borehole (survey) are executed. If the points are deviated, borehole will be directed to the point that already set before. There are many methods that can be used to determine surface point coordinates, tangential, balance tangential, average angle, radius of curvature, minimum of curvature, and mercury method (Inglis, 2005)(Zaremba, 1973) (Wilson, 1968)(Sawaryn and Thorogood, 2005). The calculation of each methods based on measurement of 3 kinds of parameter. There are, depth of well (MD), the alteration of slope (I), and the direction angle (A) which are written on the survey equipment. The first reference to the minimum curvature directional survey calculation method is credited to Mason and Taylor in 1972.(Sawaryn and Thorogood, 2005)(Taylor and Mason, 2013) Minimum of curvature method separate 2 intervals where the upper interval and lower interval. For the upper interval, inclination angle and azimuth is being used at the initial point. For the lower interval, inclination angle and azimuth is being used at the end of point. Minimum of curvature method can be seen in the fig. 1 below:

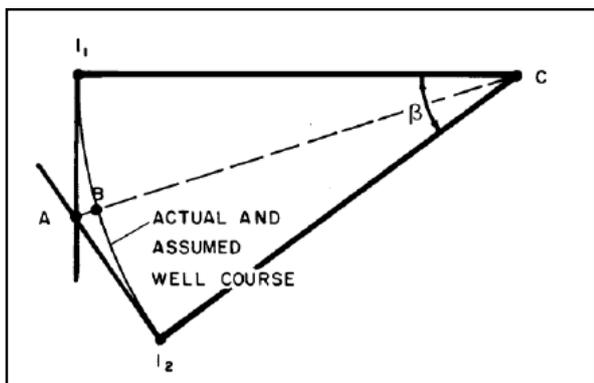


Fig 1. Minimum of Curvature Method

In this study, minimum of curvature method is used in the calculation of well track plan in well X. This method is used because it will gives the lower error than other method. Besides that, to determine the trajectory design and optimal inclination analysis for the Kick-Off Point (KOP) and End of Buildup (EOB) is done by using 3 type of sesitivities based on depth, there are 200 ft, 400 ft, and 600 ft depth.

## 2. Material and Methods

In well trajectory design, the maximum inclination angle, target distance, BUR, and azimuth must be determined in the first place. The formulas used are :

- a. Target Direction

$$d = \tan^{-1} \frac{b}{c} \quad (1)$$

- b. Target Distance ( $D_2$ )

$$a^2 = b^2 + c^2$$

$$a = \sqrt{b^2 + c^2} \quad (2)$$

- c. Build Radius

$$BUR = \frac{5729,58}{R} \quad (3)$$

$$R = \frac{5729,58}{BUR}$$

- d. Maximum Inclination

$$\angle DOC = \tan^{-1} \left( \frac{DC}{DO} \right) \quad (4)$$

$$OC = \frac{DO}{\cos \angle DOC} \quad (5)$$

$$\angle BOC = \cos^{-1} \frac{R}{OC} \quad (6)$$

$$\angle BOD = \angle BOC + \angle DOC \quad (7)$$

$$\theta = 90^\circ - \angle BOD \quad (8)$$

- e. EOB MD

$$EOB MD = v1 + \left( \frac{\theta}{BUR} \times 100 \right) \quad (9)$$

Trajectory design parameters are calculated by using minimum of curvature method. The formulas are :

$$RF = \left( \frac{2}{DL} \right) \tan \left( \frac{DL}{2} \right) \quad (10)$$

- a.

$$DL = \cos(I_2 - I_1) - \sin I_1 \sin I_2 (1 - \cos(A_2 - A_1)) \quad (11)$$

b.

$$\Delta TVD = \frac{\Delta MD}{2} (\cos I_1 + \cos I_2) RF \quad (12)$$

c. Measured Depth (ft)  $\frac{InklineationB - InklineationA}{BUR}$  (13)

d. Closure distance =  $\sqrt{N^2 + E^2}$  (14)

$$\Delta N = \frac{\Delta MD}{2} (\sin I_1 \cos A_1 + \sin I_2 \cos A_2) RF \quad (15)$$

$$\Delta E = \frac{\Delta MD}{2} (\sin I_1 \sin A_1 + \sin I_2 \sin A_2) RF \quad (16)$$

Trajectory design and optimal inclination is done by analyze the Kick-Off Point (KOP) and End of Buildup (EOB) at 200 ft, 400 ft, and 600 ft depth. The profile data of well X that being used in trajectory and incliatnin design can be seen in the table 1.

Table 1. Well Profile

Location Name	Sumur RA
Classification	Development
Tipe Well	Directional
Total Depth	2000 ft MD
Coordinate Surface	N 0°40'12,76" E 102°4'33"
Coordinate	N 0°40'9,73" / -304,37 ft N
Target	E 102°4'33" / 271,48 ft E
Target Formation	1650'sd / 1632.3 ft TVD

### 3. Results and Discussion

The coordination of target, target distance, and azimuth that used in drilling track design in well X can be seen in fig. 2. below :

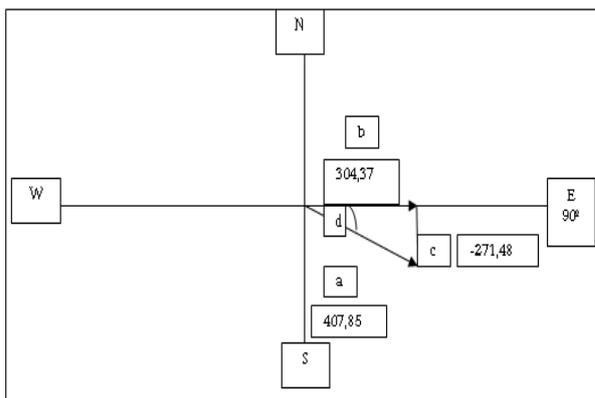


Fig 2. Plan View



Fig 3. Target Coordinate

azimuth which is the direction of drilling it self. a is the horizontal displacement, b and c is the drilling target coordination and d is the azimuth value and drilling direction.

### Trajectory design of well X at 200 ft KOP

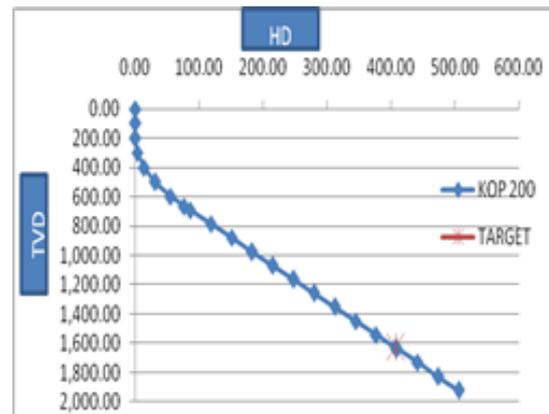


Fig 4. Trajectory Design at 200 ft KOP

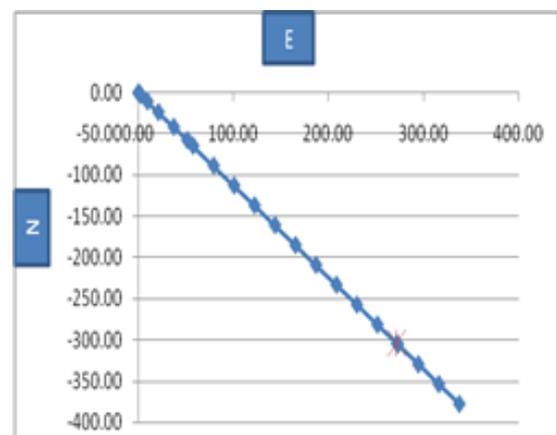


Fig 5. Vertically Track Direction

In the drilling track design category, the good track with 200 ft KOP already assumed as good criteria because the inclination is 18.87°, which is the suitable value when the inclination in drilling operation is less than 35° because in other well data if the inclination is more than 35° will caused the casing is unable to bend or the it will caused casing failure because the casing will break. The result in the 200 ft KOP are 1632.28 ft TVD and 408.16 ft AHD, when with the 200 ft KOP it will reach the target well because the desired target is 1632.3 ft and 408.75 ft AHD.

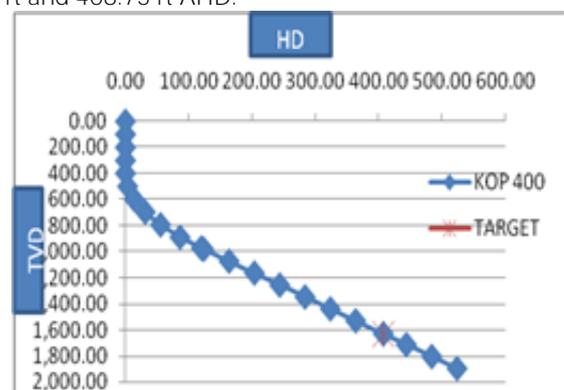


Fig 6. Trajectory design at 400 ft KOP

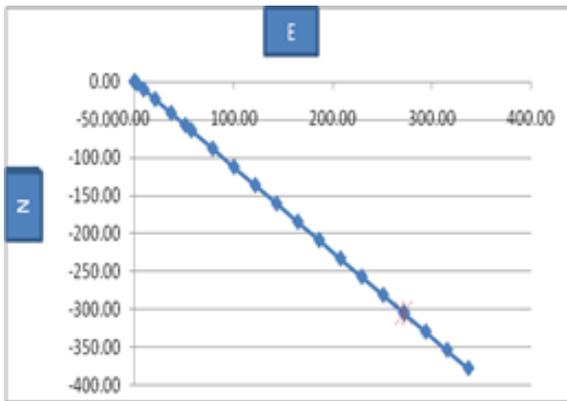


Fig 7. Direction of Vertical Track

Kick-Off Point determined at 400 ft depth in well X has 23.62° inclination, the target depth reached at 1632.41 ft TVD and 407.92 ft AHD. The good criteria is at 400 ft KOP because the inclination is below 35°

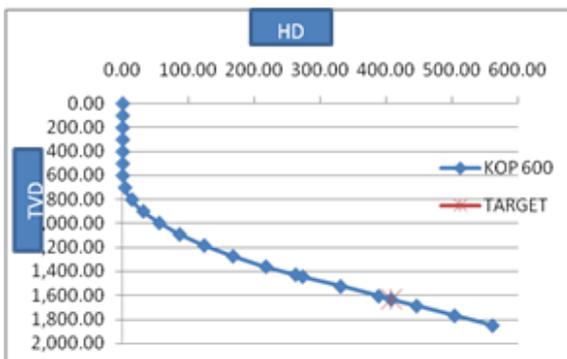


Fig 8. Trajectory Design at 600 ft KOP

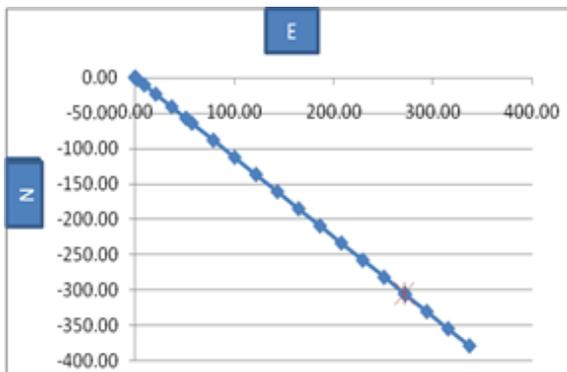


Fig 9. Direction of Vertical Track

At 600 ft KOP the maximum inclination angle is 35.26°, the target depth at 1632.43 ft TVD and 407.99 ft AHD. This depth has large the maximum inclination angle and its capability to reach the target will not be at maximum effort and if the KOP is too deep it will be reach the hard formation so the track will be hard to deflect, then it will be caused stuck pipe when tripping out because the inclination is too large. When the maximum inclination angle is too large it also cause casing failure or tubing failure when installation, and the inability to maintain when bent. Because when a drillstring need to be

bent or deflected at 600 ft sharply to reach desired target. Because in drilling track design must consider the probability of the drillstring to be bent. If the drillstring passed its limit to be bent, the drillstring will be break.

#### 4. Conclusion

According to the drilling track design to the effect of KOP and EOB depth selecton in well X, the conclusion are:

1. Optimal trajectory design at 200 ft KOP because it gives the inclination below 35° and it will reach the target very well at 1632.28 ft TVD and 408.16 ft AHD.
2. Optimal inclination at 200 ft KOP because the maximum inclination angle is 18.87°, which is good.
3. Hole problem that will occurred if the trajectory design at 600 ft are stuck pipe and inability of drillstring to be bent.

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