The Effect of Invisible Lost Time on Drilling Performance of Geothermal Wells

(Pengaruh Kehilangan Waktu Tak Tampak pada Kinerja Pemboran Sumur-sumur Panas Bumi)

Fernandez Sabar Hasudungan Pangaribuan1*, Sugiatmo Kasmunig2, Suryo Prakoso2

1PT. Schlumberger Geophysics Nusantara, Indonesia
2Petroleum Engineering Department, Faculty of Earth Technology and Energy, Universitas Trisakti, Indonesia

Abstract
Drilling activity has been focused in time on each activity to reach target depth (TD) immediately and efficiently in cost. The priority also aimed to Geothermal drilling by doing specific measurement on Invisible Lost Time (ILT) as new focus to perform. Time becomes main aspect which it would affect the cost, therefore it is important to complete the well in time manner. The research was done to analyze the offset well of well A, B, C and D in order to identify Productive Time and Non Productive Time. Key Performance Indicator (KPI) has been identified from each activity also targeted from two wells of well B dan Well D due to time efficiency used during operation. The method used by comparing offset wells then continue to identify each KPI by measuring each activity based on ASCII time and Daily Drilling Report (DDR). The result from offset wells showed inefficiency in time with Flat time 49%, Drilling 42% and non-flat time (NPT) 9% from 28 days without completion. KPI based on the crew performance has confirmed that day shift crew performed better than night shift crew. KPI on rate of penetration (ROP) on day shift crew at 6 m/hr and night crew at 3 m/hr. KPI on Weight to Weight on day shift crew at 28.43 minute/stand faster than night shift crew at 34.65 minute/stand. KPI on Tripping in cased hole on day shift crew at 4.5 minute/stand faster than night crew shift at 4.6 minute/stand. KPI on Tripping in open hole on day shift crew at 2.7 minute/stand faster than night shift crew at 3.7 minute/stand. KPI on Tripping out open hole on day shift crew at 3.0 minute/stand slower than night shift crew at 2.8 minute/stand. KPI on Tripping out cased hole on day shift crew at 3.36 minute/stand faster than night crew shift at 3.74 minute/stand. It detects of potential savings to 10 billion rupiah from both wells.

Keywords: Geothermal, Rig, Key Performance Indicator, Efficiency, Invisible Lost Time

Sari
Kegiatan pemboran saat ini dituntut untuk dapat menggunakan waktu efektif dan efisien untuk dapat mencapai target kedalaman (TD) dalam waktu yang cepat. Pengukuran performa belum pernah diakur sebagai kehilangan waktu tak tampak (ILT). Penelitian untuk menganalisis sumur offset berupa sumur A, B, C dan D untuk mengidentifikasi waktu produktif dan waktu tidak produktif. Penentuan target terhadap indicator kinerja kunci (KPI) pemboran 2 sumur berupa sumur B dan D terhadap ILT dalam efisiensi waktu. Membandingkan sumur offset dan menentukan KPI yang ditarik dengan data ASCII time dan laporan pemboran harian (DDR). Hasil 4 (empat) sumur offset menunjukkan waktu tidak efisien dengan flat time 49%, Drilling 42% dan non-flat time (NPT) 9% dari 28 hari tanpa kompleks. KPI performa crew diminara crew siang lebih baik dari crew malam. KPI ROP untuk crew pagi 6 m/hr dan crew malam 3 m/hr. KPI Weight to Weight crew pagi 28.43 menit/stand lebih baik dari crew malam 34.65 menit/stand. KPI Tripping in cased hole crew pagi 4.5 menit/stand lebih cepat dari crew malam 4.6 menit/stand. KPI Tripping in open hole crew pagi 2.7 menit/stand lebih cepat dari crew malam 3.7 menit/stand. KPI Tripping in open hole crew pagi 3.0 menit/stand lebih lambat dari crew malam 2.8 menit/stand. KPI Tripping out cased hole crew pagi 3.36 menit/stand lebih cepat dibandingkan crew malam 3.74 menit/stand. ILT menunjukkan performa yang tidak efisien sebesar 20% atau rata-rata 5 hari terhadap 1 sumur. Dengan potensi efisiensi sebesar 10 milyar Rupiah terhadap dua sumur.

Kata-kata kunci: Panas bumi, Rig, Indikator Kinerja Kunci, Efisiensi, Kehilangan Waktu Tak Tampak

*Corresponding author
E-mail: fernandez.pangaribuan@gmail.com
Tel: +(62) 85280239537

I. INTRODUCTION
Geothermal in Indonesia still struggling to face the challenge in exploration to find new geothermal source with high uncertainty. Drilling cost has affected to the operations in order to keep the operation time as low. After 2017, PLN has drilled 4 exploration wells in eastern part of Indonesia. These four wells were drilled to TD depth at 1800 mMD. During the activities, there were many challenges related to formation, equipment, personnel experience which effect to time duration over than the plan time. Related to operation cost,
drilling performance was defined which focus on crew activity during the operation. The KPI has been identified and targeted to look at the area of potential time saving. This would affect the cost per well during execution. Never the less, KPI being determined to investigate each activity to segregate in which area of activities has given high loss during drilling. Each KPI will give focus activity in time and look forward in how to improve performance. This process will help to lead on reducing wasted time in drilling as known as ILT (Figure 1) [1, 2, 3, 7].

II. MATERIAL AND METHOD

2.1 Material

In this study used historical data from ASCII time, DDR (Daily Drilling Report) also Drilling Program from PLN (Persero) then the data being analyzed by comparing both data to look into deep activities and recalculate the time both Planning and actual time of each activity. The process being QC on each data availibility from previous 4 (four) wells to 2 (two) wells can be process and analyzed. From those 2 (wells) then being identified of each activity into KPI processed on excel. Each of KPI then being targeted to get the ILT (Invisible Lost Time) [6, 11].

2.2 Method

Using tool called Rigstate to measure and analyze hidden NPT/Invisible Lost Time. KPI identification is needed to define and targeted before calculating the ILT. By combining both ASCII time and DDR, it would be useful to identify each activity more accurate to get exact time of each activity/KPI. Related to this research, there are six steps to run the analysis (Figure 2) such as [6, 8]:

Step 1: Data selection from 4 (four) wells (Sumur A, B, C and D) and data QC.

Step 2: Evaluate 4 (four) wells by comparing those wells to get complete view of all the operations happened.

Step 3: Offset well analysis through their time and activities (2 wells) identification such as Rig Up, Make Up Drilling BHA, Run in hole, Tripping out connection time, Run casing, Stand time etc and focus on crew performance by calculating Rigstate from ASCII Time and DDR [5].

Step 4: Detailed operation to define target from each KPI which has been identified from both Flat time and Non Flat time. Flat time is related to surface activity (M/U Drilling BHA, L/D Drilling BHA, N/U BOP, N/D BOP, Install ADA Tool). Non Flat time is related to borehole activity (Average ROP, Tripping in cased hole connection

---

![Flow Chart of the Research](image)

Figure 1. Well Duration

Figure 2. Flow Chart of the Research
Step 5: Calculate ILT based on target KPI which has been determined. Recalculating Rigstate to get proper result on each of activities.

Step 6: Monitoring the KPI target to improve performance and manage the accuracy on well duration time on TVD (Time versus Depth).

III. RESULTS AND DISCUSSION

Data selection and data quality control started from 4 (four) wells which came from Final report. These reports have been processed to identify Productive Time (PT), Non Productive Time (NPT). Continued to analyze the KPI from 2 (two) wells and measuring Rigstate in order to identify specific KPI and identify crew performance. All of those KPI are used to measure ILT.

Step 1: Data selection and quality control. Data was selected from 4 (four) wells sumur A, B, C and D with ASCII Time (Total depth, Bit depth, Hookload, Block position, SPP, Flow rate, Surface RPM, Surface Torque), DDR, Drilling program. During quality control found out only Sumur B and D were able to use for further analysis until identifying ILT.

Step 2: Time measurement A, B, C and D Wells Detailed analysis on time from the well operations in order to identify each of activity (A.W. Iyoho et al, 2004). The data source was taken from Final Well Report as given in Table 1 and extracted the data manually. The analysis will identify time planning and actual time in drilling operations which have been drilled as listed in Table 2.

Further analysis is identifying duration time into specific activities to drilling (Non Flat time), Flat time and NPT to get specific activities mostly spent. These 4 (four) wells are identified inefficiency during operation as shown average Flat time at 49% higher than drilling time at 42% from actual time in drilling operations with average actual time 28 days (without completion). In the following table shown below comparison duration time on specific activities (Table 3).

Step 3: Offset well analysis from 2 wells Data was selected from 4 (four) wells sumur A, B, C and D with ASCII Time (Total depth, Bit depth, Hookload, Block position, SPP, Flow rate, Surface RPM, Surface torque) (Table 4) and DDR are used to identify KPI (Table 5). Time measurement of each KPI is more usefull by combining both data from ASCII Time and DDR (Syed Ali Raza et al, 2017). Rigstate calculation is run to get time specific of the activities then these KPI can be usefull to identify crew performance within their shift.

To calculate crew performance, the KPI are being classified into two part where as Flat time and Non Flat time. Most likely Non Flat time is used to identify crew performance whereas related to rig activities during drilling. This is closely to pipe connection time between crew shift in day and night. This can be seen on this table below (Table 6). Crew performance can be detected during pipe connection time either fast or not. This measurement never been detected before during operation which always identify as normal activities. This could be usefull to be used to look at the exact number and put into proper target to see the improvement. Crew performance can be differentiation from their shift between night and day. The result shown below on the figure on each KPI activities.

ROP Performance

The ROP performance of each crew in day and night shift showed that day shift crew performed better than night crew shift. Day shift crew can perform ROP to 6 m/hr compared to night shift crew that only performed to 3 m/hr in average applied to all section (Figure 3).

This ROP plot showed above against target (red color) compared to actual ROP (green and orange color) still far to reach the goal. As shown on Sumur B and Sumur D showed tendency of dropping in ROP every section as concluded no improvement.

Weight to Weight Performance

Crew performance related to weight to weight was identified to see each connection time per stand during drilling. The interval will be closed to stand down while reaming the hole before taking connection, connection and after connection time. The overall showed that time spent during pre connection time and connection time. It concludes that the formation took a part while drilling as hard formation. The result was a day crew performed better than night crew. Day crew can perform weight to weight connection average to 28.43 minute/stand compared to night crew perform to 34.65 minute/stand applied to whole section (Tables 7 and ) [4].

In following tables above, from Sumur B compared to Sumur D showed inconsistency on Weight to Weight time while drilling of each section. This inconsistency on Weight to Weight could be affected by formation difficulties while reaming the pipe before connection so it took extra time to clean borehole regurally. It is often while formation losses, the action to use air drilling and optimized the flowrate in order to lift up cuttings to surface as it started from surface section to production section.
Tripping in/out cased and open hole performance

This KPI related to connection time while tripping in and tripping out both cased hole and open hole. From both wells on Sumur B and Sumur D showed consistency with average connection time 3.12 minute/stand to 3.55 minute/stand. KPI on Tripping in cased hole on day shift crew at 4.5 minute/stand faster than night crew shift at 4.6 minute/stand (Table 9). KPI on Tripping in open hole on day shift crew at 2.7 minute/stand faster than night shift crew at 3.7 minute/stand (Table 10). From the table showed night crew spent time in connection in 17.5” section and 8.5” section. KPI on Tripping out open hole on day shift crew at 3.0 minute/stand slower than night shift crew at 2.8 minute/stand (Table 11). Night crew spent more time in connection in 17.5” section and 12.25” section. KPI on Tripping out cased hole on day shift crew at 3.36 minute/stand faster than night crew shift at 3.74 minute/stand (Table 12). From both wells can be concluded that day crew performed better than night crew. In this case related to solution, swabbing the crew needed to improve performance in order to share proper experience among them.

Casing Speed

KPI while tripping in casing is important to measure it due to rig time. Formation, borehole inclination and mud have an important role while running in casing to TD within short time. Geothermal field would have unpredictable with stuck pipe risk. KPI for casing speed both wells have different casing speed. Casing speed for 13.375” casing (blue color) on Sumur B and Sumur D was not improving with tendency to drop in joint count to 8 joint/hr. Casing speed for 9.625” casing (orange color) Sumur B and Sumur D was showing some improvement over time in count to 9 joint/hr (Figure 4).

Step 4: Detailed operation to define target

Separate the operation on Sumur B and Sumur D into two parts which are known as Flat time and Non Flat time. There are many KPI from being identified and defined to target in the following table below (Table 13 and Table 14). From the table, the KPI target is not available related to activity on certain section.

Step 5: Calculate ILT based on target KPI

ILT calculation is done from targeted KPI both wells. Formula is used by different part from Flat time and Non Flat time.

\[
\text{ILT Flat Time} = \text{AT (hrs)} - \text{TT (hrs)} \quad (1)
\]

where AT is actual time and TT is target time.

If the actual time over target plan then ILT will appear and if the actual time below target plan then there is no ILT.

\[
\text{ILT Non Flat Time} = \text{ATs (hrs)} - \text{TTs (hrs)} \quad (2)
\]

where ATs is actual time from stand and TTs is target time from stand.

If the actual time from every stand over the target plan then ILT applied each stand and if the actual time per stand below target plan then there is no ILT.

ILT result at Lapangan “X” between Sumur B and Sumur D based on KPI target are showing inconsistency during operation time to time with no improvement (Table 15 and Table 16). ILT on Sumur B from all section to 5.67 days with time breakdown on 17.5” section to 2.01 days, 12.25” section to 1.52 days and 8.5” section to 2.14 days. On Sumur D, total ILT identified to 5.17 days with breakdown on 17.5” section to 0.68 days, 12.25” section to 1.23 days, and 8.5” section to 3.28 days.

Total ILT from both wells to 20 % or 5 days inefficiency on each well. From the operation cost per day to 1 (one) billion rupiah, it detects of potential savings to 10 billion rupiah from both wells.

Step 6: Monitoring the KPI target

This part is important as commitment to achieve the goal. After the ILT is identified from the KPI target. It is recommended to focus on low achievement KPI. Providing new TvD can be done as a new recommendation to next well.

IV. CONCLUSIONS

The results from the analysis from 4 wells to improve performance by strategy from KPI target as the objective to achieve performance.

1. There is no improvement based on 4 wells by deviding the operation into 3 activities to Flat time 49%, Drilling 42% and NPT 9% with average actual days per well to 28 days without completion.

2. Performance crew by KPI from ROP, Weight to Weight, Connection time and casing speed resulted of day shift crew performed better than night shift crew.

3. Total ILT detected from Sumur B and Sumur D average to 5 days on each well with potential saving ro 10 billion rupiah.

4. Determine KPI activities based on analysis from ASCII Time and DDR

5. From the research, couple KPI need to improve as part of achievement such as M/U Drilling BHA, L/D Drilling BHA, N/U BOP’s, Install ADA Tool, Circulation section, Cement job, Wait on cement, R/U Casing equipment, R/D
Casing equipment, RIH Connection time in cased hole, Average ROP, Weight to Weight connection, POOH Connection time in open hole, POOH Connection time in cased hole.

REFERENCES

1. Raza, S.A., Al-Braik, H., Attalah, M., Corona, M., and Kojadinovic, N., 2017. Performance Enhancement of Drilling and Completions Operations in Giant Offshore Field Abu Dhabi by Tracking and Monitoring Invisible Lost Time and Defined KPIs. Society of Petroleum Engineers, SPE 188238-MS.

2. Al-Shamsi, J., Al-Nauimi M., Al-Hosani, F., and Al-Sairi, A., 2018. Invisible Lost Time Initiative ILT in Drilling Toward More Efficiency, High Performance and High Profitability-Do More with Less. Society of Petroleum Engineers. SPE-192969-MS.

3. Iyoho, A.W., Millheim, K.K., and Virginillo, B.K., 2004. Methodology and Benefits of a Drilling Analysis Paradigm. Society of Petroleum Engineers, SPE 87121-MS.

4. Brett, J.F. and Millheim, K.K., 1986. The Drilling Performance Curve: A Yardstick for Judging Drilling Performance. Society of Petroleum Engineers, SPE 15362-MS.

5. Bond, D.F., Scott, P.W., Page, P.E., and Windham, T.M., 1998. Step Change Improvement and High Rate Learning are Delivered by Targeting Technical Limits on Sub-Sea Wells. Society of Petroleum Engineers, SPE 35077.

6. Freithofnig, H.J., Spoerker, H.F., and Thonhauser, G., 2003. Analysis of Hook Load Data to Optimize Ream and Wash Operations. Society of Petroleum Engineers, SPE 85308.

7. Hellstrom, A.H.K., 2010. Statoil Drilling and Well Learning Curves, Experience and Theory Is there a learning curve from drilling the first well with a new rig and onwards? Master Thesis, University of Stavanger, Norway.

8. JICA Report, 2011. JICA Preparatory Survey for Tulehu Geothermal Power Plant. Jakarta, Indonesia.

9. Maidla, E.E. and Maidla, W.R., 2010. Rigorous Drilling Nonproductive-Time Determination and Elimination of Invisible Lost Time: Theory and Case Histories. Society of Petroleum Engineers, SPE 138804-MS.

10. Noerager, J.A., Norge, E., White, J.P., and Floetia, A., 1987. Drilling time Predictions from Statistical Analysis. SPE 16164-MS.

11. Spoeker, H.F, Maidla E.E., and Thonhauser, G., 2011. Rigorous Identification of Unplanned and Invisible Lost Time for Value Added Propositions Aimed at Performance Enhancement. Society of Petroleum Engineers, SPE 138922-MS.
Table 1. Planning Time

| Start day | End day | Start depth(m) | End depth(m) | Phase | Hole Size " | Description |
|-----------|---------|----------------|--------------|-------|-------------|-------------|
| 0         | 0       | 0              | 0            | F-26  | 26          | Move Rig    |
| 0         | 0.38    | 40             | 40           | F-175 | 17.5        | Make up 17-1/2" Pilot BHA |
| 0.38      | 0.63    | 400            | 400          | F-175 | 17.5        | Drill 17-1/2" Pilot Hole to 40 mtr |
| 0.63      | 1.01    | 400            | 400          | F-175 | 17.5        | CHC, POOH, rack back 17-1/2"BHA, and M/U26"BHA |
| 1.01      | 1.22    | 400            | 400          | F-175 | 17.5        | Drill 26" Hole to 40 mtr (enlarge) |
| 1.22      | 1.41    | 400            | 400          | F-175 | 17.5        | M/U, RIH 20" Casing+Stab in Stinger and Circulation |
| 1.41      | 1.91    | 400            | 400          | F-175 | 17.5        | Cement 20" Casing, POOH Stab in Stinger, and WOC |
| 1.91      | 2.58    | 400            | 400          | F-175 | 17.5        | Cut 20" Casing and Install 21-1.4"Temp Wellhead, N/U 21-1/2"Diverter Stack |
| 2.58      | 2.83    | 400            | 400          | F-175 | 17.5        | M/U 17-1/2" Steerable BHA, RIH, Drillout cement and 20" shoetrack |
| 2.83      | 5.56    | 400            | 400          | F-175 | 17.5        | Drill 17-1/2" Hole to 400 mtr |
| 5.56      | 5.88    | 400            | 400          | F-175 | 17.5        | Conduct wiper trip, CHC, Pump Hivis |
| 5.88      | 6.2     | 400            | 400          | F-175 | 17.5        | POOH and Lay Down 17-1/2"BHA |

Table 2. Duration time of A, B, C and D Wells

| Wells | Spud Date       | End date         | Plan (days) | Actual (days) |
|-------|-----------------|------------------|-------------|---------------|
| A     | 21/06/2017 @ 00:00 | 11/08/2017 @ 01:45 | 30.00       | 50.16         |
| B     | 01/09/2017 @ 07:00  | 30/09/2017 @ 00:00 | 30.00       | 26.65         |
| C     | 11/10/2017 @ 22:00 | 15/11/2017 @ 00:00 | 30.00       | 30.81         |
| D     | 19/12/2017 @ 00:00  | 25/01/2018 @ 09:00 | 29.73       | 30.38         |

Table 3. Duration time of A, B, C and D Wells

| Wells | Drilling (%) | Flat time (%) | NPT (%) |
|-------|--------------|---------------|---------|
| A     | 26           | 54            | 20      |
| B     | 44           | 53            | 3       |
| C     | 55           | 38            | 7       |
| D     | 46           | 49            | 5       |
Table 4. Mudlogging ASCII Time

| Date       | Time     | Block Pos | ROIm/ hr | Mfc/kft | Drill Depth m | RPMs c/min | Torque kft/lb | SpPress psi | Mud Flowin gpm | Bit Depth m | Scfm Air Flowin gpm | Air Press psi |
|------------|----------|-----------|----------|---------|----------------|-------------|---------------|-------------|-----------------|--------------|---------------------|-------------|
| 12/28/2017 | 00:00:00 | 11        | 0        | 44      | 0              | 0           | 0             | 0           | 0               | 0            | 0                   | 0            |
| 12/28/2017 | 00:00:10 | 11        | 0        | 44      | 0              | 0           | 0             | 0           | 0               | 0            | 0                   | 0            |
| 12/28/2017 | 00:00:15 | 11        | 0        | 44      | 0              | 0           | 0             | 0           | 0               | 0            | 0                   | 0            |
| 12/28/2017 | 00:00:20 | 11        | 0        | 44      | 0              | 0           | 0             | 0           | 0               | 0            | 0                   | 0            |
| 12/28/2017 | 00:00:25 | 11        | 0        | 44      | 0              | 0           | 0             | 0           | 0               | 0            | 0                   | 0            |
| 12/28/2017 | 00:00:30 | 11        | 0        | 44      | 0              | 0           | 0             | 0           | 0               | 0            | 0                   | 0            |
| 12/28/2017 | 00:00:35 | 11        | 0        | 44      | 0              | 0           | 0             | 0           | 0               | 0            | 0                   | 0            |
| 12/28/2017 | 00:00:40 | 11        | 0        | 44      | 0              | 0           | 0             | 0           | 0               | 0            | 0                   | 0            |
| 12/28/2017 | 00:00:45 | 11        | 0        | 44      | 0              | 0           | 0             | 0           | 0               | 0            | 0                   | 0            |
| 12/28/2017 | 00:00:50 | 11        | 0        | 44      | 0              | 0           | 0             | 0           | 0               | 0            | 0                   | 0            |
| 12/28/2017 | 00:01:00 | 11        | 0        | 44      | 0              | 0           | 0             | 0           | 0               | 0            | 0                   | 0            |

Table 5. Daily Drilling Report

| Bone-hole | Daily Cost | Well Comp | Phase | Interval | Stimulation | Borehole Section | Start Time | End Time | Duration (h) | Start Depth m | End Depth m | Operation |
|-----------|------------|-----------|-------|----------|-------------|------------------|------------|----------|--------------|---------------|-------------|-----------|
| TLU-D-01ST| INTDRL     |           |       |          |             |                  | 12:25      | 12/7/17  | 11.75        | 640           | 640         | Drill     |
| TLU-D-01ST| INTDRL     |           |       |          |             |                  | 12:25      | 12/7/17  | 10.25        | 640           | 643.6       | Drill     |
| TLU-D-01ST| INTDRL     |           |       |          |             |                  | 12:25      | 13/7/17  | 5.8          | 643.6         | 644        | Drill     |
| TLU-D-01ST| INTDRL     |           |       |          |             |                  | 12:25      | 13/7/17  | 0.33         | 644           | 644.97      | Drill     |
| TLU-D-01ST| INTDRL     |           |       |          |             |                  | 12:25      | 13/7/17  | 0.62         | 644.97        | 653         | Drill     |
| TLU-D-01ST| INTDRL     |           |       |          |             |                  | 12:25      | 13/7/17  | 2.25         | 653           | 655.5       | Drill     |
| TLU-D-01ST| INTDRL     |           |       |          |             |                  | 12:25      | 13/7/17  | 10.75        | 655.5         | 666.37      | Drill     |
| TLU-D-01ST| INTDRL     |           |       |          |             |                  | 12:25      | 13/7/17  | 1.7          | 666.37        | 670         | Drill     |
| TLU-D-01ST| INTDRL     |           |       |          |             |                  | 12:25      | 13/7/17  | 1.55         | 670           | 670         | Drill     |
| TLU-D-01ST| INTDRL     |           |       |          |             |                  | 12:25      | 13/7/17  | 0.28         | 671           | 671         | Drill     |
| TLU-D-01ST| INTDRL     |           |       |          |             |                  | 12:25      | 14/7/17  | 0.28         | 673.9         | 673.9       | Drill     |
| TLU-D-01ST| INTDRL     |           |       |          |             |                  | 12:25      | 14/7/17  | 0.3          | 673.9         | 688.06      | Drill     |
| TLU-D-01ST| INTDRL     |           |       |          |             |                  | 12:25      | 14/7/17  | 1.88         | 673.9         | 688.06      | Drill     |
| TLU-D-01ST| INTDRL     |           |       |          |             |                  | 12:25      | 14/7/17  | 0.13         | 686.06        | 686.06      | Drill     |

Table 6. Non Flat time KPI

| Non Flat time KPI                                |     |
|-------------------------------------------------|-----|
| Average ROP (m/hr)                              |     |
| Weight to Weight time (Pre connection time)      |     |
| Weight to Weight time (Connection time)          |     |
| Weight to Weight time (Post connection time)     |     |
| RIH Connection time in cased hole               |     |
| RIH Connection time in open hole                 |     |
| POOH Connection time in cased hole              |     |
| POOH Connection time in open hole               |     |
| Run Casing joint Connection time                |     |
Figure 3. ROP comparison Sumur B and D

Table 7. Weight to weight Sumur B

| Well /Section | Crew Shift | Pre Conn (min/std) | Conn (min/std) | Post Conn (min/std) |
|---------------|------------|--------------------|----------------|--------------------|
| B/17.5”       | Day        | 9.96               | 8.44           | 2.58               |
| B/17.5”       | Night      | 21.75              | 8.85           | 3.21               |
| B/12.25”      | Day        | 9.33               | 5.81           | 2.14               |
| B/12.25”      | Night      | 13.84              | 8.56           | 3.18               |
| B/8.5”        | Day        | 15.19              | 5.31           | 6.31               |
| B/8.5”        | Night      | 15.60              | 5.30           | 2.23               |

Table 8. Weight to weight Sumur D

| Well /Section | Crew Shift | Pre Conn (min/std) | Conn (min/std) | Post Conn (min/std) |
|---------------|------------|--------------------|----------------|--------------------|
| D/17.5”       | Day        | 21.82              | 6.38           | 3.17               |
| D/17.5”       | Night      | 33.85              | 7.62           | 7.54               |
| D/12.25”      | Day        | 17.93              | 5.14           | 5.68               |
| D/12.25”      | Night      | 21.74              | 5.49           | 8.12               |
| D/8.5”        | Day        | 33.31              | 5.49           | 6.64               |
| D/8.5”        | Night      | 25.34              | 5.15           | 7.27               |
Table 9. Tripping in connection time cased hole

| Well | Section | Crew shift | Average Conn. time (min/std) |
|------|---------|------------|-----------------------------|
| B    | 17.5”   | Day        | 6.35                        |
| B    | 17.5”   | Night      | 0.00                        |
| B    | 12.25”  | Day        | 5.36                        |
| B    | 12.25”  | Night      | 3.50                        |
| B    | 8.5”    | Day        | 3.41                        |
| B    | 8.5”    | Night      | 2.68                        |
| D    | 17.5”   | Day        | 0.00                        |
| D    | 17.5”   | Night      | 5.15                        |
| D    | 12.25”  | Day        | 2.26                        |
| D    | 12.25”  | Night      | 5.87                        |
| D    | 8.5”    | Day        | 2.62                        |
| D    | 8.5”    | Night      | 2.79                        |

Table 10. Tripping in connection time open hole

| Well | Section | Crew shift | Average Conn. time (min/std) |
|------|---------|------------|-----------------------------|
| B    | 17.5”   | Day        | 0.00                        |
| B    | 17.5”   | Night      | 4.68                        |
| B    | 12.25”  | Day        | 2.98                        |
| B    | 12.25”  | Night      | 0.00                        |
| B    | 8.5”    | Day        | 2.39                        |
| B    | 8.5”    | Night      | 2.79                        |
| D    | 17.5”   | Day        | 0.00                        |
| D    | 17.5”   | Night      | 0.00                        |
| D    | 12.25”  | Day        | 0.00                        |
| D    | 12.25”  | Night      | 0.00                        |
| D    | 8.5”    | Day        | 4.24                        |
| D    | 8.5”    | Night      | 5.17                        |

Table 11. Tripping out connection time open hole

| Well | Section | Crew shift | Average Conn. time (min/std) |
|------|---------|------------|-----------------------------|
| B    | 17.5”   | Day        | 6.35                        |
| B    | 17.5”   | Night      | 0.00                        |
| B    | 12.25”  | Day        | 5.36                        |
| B    | 12.25”  | Night      | 3.50                        |
| B    | 8.5”    | Day        | 3.41                        |
| B    | 8.5”    | Night      | 2.68                        |
| D    | 17.5”   | Day        | 0.00                        |
| D    | 17.5”   | Night      | 5.15                        |
| D    | 12.25”  | Day        | 2.26                        |
| D    | 12.25”  | Night      | 5.87                        |
| D    | 8.5”    | Day        | 2.62                        |
| D    | 8.5”    | Night      | 2.79                        |
Table 12. Tripping out connection time cased hole

| Well | Section | Crew shift | Average Conn. time (min/std) |
|------|---------|------------|-----------------------------|
| B    | 17.5"   | Day        | 6.35                        |
| B    | 17.5"   | Night      | 0.00                        |
| B    | 12.25"  | Day        | 5.36                        |
| B    | 12.25"  | Night      | 3.50                        |
| B    | 8.5"    | Day        | 3.41                        |
| B    | 8.5"    | Night      | 2.68                        |
| D    | 17.5"   | Day        | 0.00                        |
| D    | 17.5"   | Night      | 5.15                        |
| D    | 12.25"  | Day        | 2.26                        |
| D    | 12.25"  | Night      | 5.87                        |
| D    | 8.5"    | Day        | 2.62                        |
| D    | 8.5"    | Night      | 2.79                        |

Table 13. KPI target Flat time

| KPI             | 17.5" Target (hrs) | 12.25" Target (hrs) | 8.5" Target (hrs) |
|-----------------|---------------------|---------------------|-------------------|
| M/U Drilling BHA| 7.07                | 5.00                | 2.02              |
| L/D Drilling BHA| 1.75                | 1.50                | 1.00              |
| N/U BOP         | 5.97                | 7.00                | N/A               |
| Pressure test BOP | N/A                | 1.85                | N/A               |
| Install ADA tool| 2.00                | N/A                 | N/A               |
| Circulation section | 1.78              | 1.50                | 1.58              |
| Cement job      | 6.48                | 2.49                | N/A               |
| Wait on cement  | 9.50                | 5.09                | N/A               |
| Wellhead work   | 10.98               | N/A                 | N/A               |
| R/U casing equipment | 1.75              | 1.25                | N/A               |
| R/D casing equipment | N/A              | N/A                 | N/A               |
| Drill out cement | N/A                 | 6.34                | 7.67              |

Table 14. KPI target Non Flat time

| KPI                          | 17.5" Target (min/std) | 12.25" Target (min/std) | 8.5" Target (min/std) |
|------------------------------|------------------------|-------------------------|-----------------------|
| RIH Connection time in cased hole | 5.83                   | 3.75                    | 2.33                  |
| RIH Connection time in open hole | 3.67                   | 2.96                    | 2.67                  |
| RIH Speed in cased hole       | 1.50                   | 2.08                    | 1.25                  |
| RIH Speed in open hole        | 2.33                   | 2.25                    | 1.38                  |
| Average ROP                  | 176.79 or 9.5 m/hr     | 214.04 or 7.85 m/hr    | 274.71 or 6.12 m/hr   |
| Weight to Weight (Preconnection time) | 21.08               | 16.79                   | 21.83                 |
| Weight to Weight (Connection time) | 6.50                | 5.67                    | 5.13                  |
| Weight to Weight (Post connection time) | 2.92                | 5.08                    | 3.50                  |
| POOH Connection time in open hole | 3.33                   | 2.58                    | 2.46                  |
| POOH Speed in open hole       | 2.33                   | 2.42                    | 2.33                  |
| POOH Connection time in cased hole | 3.54                   | 2.92                    | 2.33                  |
| POOH Speed in cased hole      | 1.33                   | 1.83                    | 2.00                  |
| Run Casing Connection time in cased and open hole | 4.04                   | 6.42                    | N/A                   |
| Run Casing Speed in cased and open hole | 1.67                   | 2.38                    | N/A                   |
Table 15. Total ILT of B Well

| Section  | Actual time (days) | ILT (days) | NPT (days) |
|----------|--------------------|-----------|------------|
| 17.5"    | 5.48               | 2.01      | 0.00       |
| 12.25"   | 4.94               | 1.52      | 0.31       |
| 8.5"     | 9.17               | 1.52      | 2.14       |

Table 16. Total ILT of B Well

| Section  | Actual time (days) | ILT (days) | NPT (days) |
|----------|--------------------|-----------|------------|
| 17.5"    | 9.07               | 0.68      | 1.52       |
| 12.25"   | 11.29              | 1.23      | 0.00       |
| 8.5"     | 16.71              | 3.28      | 0.00       |

Figure 4. Casing speed of B and D Wells