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Integrated Application of ESP & Sand Control in Sandy and Gassy Wells

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Integrated Application of ESP & Sand Control in Sandy & Gassy Wells

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Abstract

Production optimization by Gas Lift to ESP Conversion in SK field present challenges for pumps to handle low production, gassy and sandy wells (proppant, hydraulically fractured) in TLS zone. Low ESP run-life were experienced due to these wells conditions. An integrated ESP with special gas & sand handling equipment are required to improve the performance and run-life of the ESP systems to succeed the conversion program.

The ESP conversion for TLS zone initiated by trial on 3-wells, which considers low liquid rate, high gas production, potential sand (proppant) intrusion into ESP string. These considerations affecting the selection of the suitable pumps, and additional equipment by providing sand control and gas separation systems to handle gas and sand. Based on the trial results some notes are taken prior continuing the extensive application to other TLS wells. More extensive application is currently in progress, with 13-wells currently installed and another 12-wells to be installed within this year.

The trials were completed in 2014-2015 with promising result. ESP's were able to operate more than 200 days without downhole failures. The ESP string were installed below perforation and completed with gas separation. Casing shroud and sand screen were installed in 2-wells only, while 1-well was not equipped with screen due to casing size limitation. No sand problem & pump stuck reported until end of the rental time. 13-additional wells were then installed in 2016-2017. Current average run-life are 400-days, with the longest run life 663-days. The shortest run life occurred to 1-well without sand screen, with only 30-days operation prior pump stuck because of sand problem. In total, 3-wells suffered from sand problem since there were no sand screen installed (5.5" casing size).

As lesson learn from the previous conversion, a study has been done to provide completion string for sand screen installation in 5.5" casing. It is expected there will be no downhole failures caused by sand problem in the next installation. The integrated ESP with Gas & Sand handling application in SK field has successfully reduced the needs of ~3 MMSCFD of GL recycle, and expected to reduce another ~3 MMSCFD within this year

Keywords: production optimization, ESP, gassy and sandy wells

1. Introduction

SK field is a mature field, located onshore in South Sumatera, Indonesia. This field was discovered in 1996 and the oil production was started in 1998 from 2 hydrocarbon formations: Talang Akar Sandstone (TAF) and Baturaja Carbonate (BRF). Recently Telisa sandstone (TLS) in 2002 were developed with hydraulic fracturing treatment. Gas lift (GL) system was firstly introduced in year 2000 as the main artificial lift. In 2006, the gas source was started declining and the first electrical submersible pump (ESP) was installed in BRF reservoir as alternative artificial lift beside gas lift. The successful installation of ESPs made large-scale artificial lift conversion in between year 2009 to 2010. Approximately 84 wells from total 193 active wells were converted from GL to ESP. As the gas availability continues to decline, then the GL-ESP conversion is more encouraged. Currently, ESP has become the dominant AL in SK Field which consists of 145 ESP and 47 GL yearly average active wells. The AL population in SK Field in the last 10 years is shown in Figure-1.

2. Problem Statement

Telisa (TLS) is a sandstone reservoir that producing oil in SK field. It has characteristic of very low permeability so that the well cannot be produced without stimulation. A hydraulic fracturing treatment is needed to produce hydrocarbon from TLS formation. During the production phase, some amount of proppant were produced to wellbore and may enter the ESP pump, which leading to plugging and erosion. The proppant's sand will cause the wearing at pump stages and may damage the mechanical seal due to vibration. Figure 2 showed the ESP failure due to proppant sand.

In addition, the production test showed that high free gas enters the pump which may cause pump gas lock.

Therefore, an integrated ESP with special gas & sand handling equipment are required to improve the performance and run-life of the ESP systems.

3. Methodology

The methodology for this project, based on literature study, laboratory test, and real field implementation. We combine all of those methodology to ensure the success result of this project.

Well Data and Completion Design

The initial well completion design is cased hole perforated with hydraulic fracturing. The casing size is 5.5-inch and 7-inch. The wells were produced using artificial lift (gas lift) with 2-7/8" tubing. The typical of initial well completion design is shown in Figure-3. Along with field development plan, the gas lift systems were converted into ESP systems due to field's gas shortage.

Type of Sand Control

Sand control methods have become more varied in the recent years. In general, sand control can be grouped as follows:

- Production rate control
- Selective and oriented perforating
- Mechanical stressing of the formation
- Sand packing
- In situ sand consolidation
- Resin coated gravel packing without a screen
- Mechanical control (prepacked, stand alone, expandable screen, etc)
- Gravel packing, open hole and inside casing
- Propped fracturing including frac packing

Proppant sand is considered as well-sorted, clean sand with a large grain size thus stand-alone screen is selected as sand control. Besides the screen is considered low cost completion and fit with existing completion design.

The sand screen is installed below the ESP systems by using shroud systems as shown in Figure-4. The shroud systems will force the reservoir fluid to pass through the sand screen before enter to ESP pump intake. The screen filters the proppant sand out from the fluid produced by the ESP systems and it will protect the ESP systems from proppant sand.

Screen Design

The screen selected is expected to prohibit the flow of proppant sand into pump intake. The angular shaped pores ranging in size from 15 to 600 microns are difficult to plug because they retain harmful sand while allowing fines smaller than 30 microns to pass through. These fines would otherwise get trapped at the sand-screen interface and cause plugging over time. The screens have a 40% open flow area and 3,000 D air permeability which result in almost no additional resistance to flow across the screen.

Shroud Systems

Shroud is basically used to redirect the flow of production fluid around the ESP system. In this completion design, the production fluid will flow through sand screen before enter the pump intake. By using the shroud, the pump can be installed below the perforation and the production fluid redirect to flow down and back up to cooling down the motor. The purpose of setting below perforation is to slightly increase production rate at the same pump intake pressure as well as acting as simple gas separation systems. In this configuration, the fluid velocity across the motor is increasing so the cooling flow requirement can be met in low production rate well.

In summary, the ESP completion design will give advantages:

- Minimizes proppant sand content that entering the ESP pump by passing the production fluid through sand screen
- Increases the production rate by setting pump below perforation
- Serves as simple gas separation systems
- Increases cooling velocity for low production rate well

4. Case Study

The project trials were proposed and completed for three (3) wells in 2014, but only two (2) wells that completed with shroud and screen. One (1) well was not equipped with sand screen due to casing size limitation.

Well X-1

The ESP was installed at well X-1 in Dec 2014 completed with gas-separator system, shroud and sand screen. Pump intake is set below the perforation interval. The well could produce at around 200 BLPD and 35 BOPD. In Oct 2015, the ESP string was pulled-out due to end of rental time. ESP lifetime in this well is around 290-days.

Well X-2

The second well X-2, the ESP was installed in Dec 2014 and completed also with gas-separator system, shroud and sand screen. Pump intake is set across the perforation interval. The well could produce up to 256 BLPD and 248 BOPD. In July 2015, the ESP string was pulled-out due to end of rental time. ESP lifetime in this well is around 219-days.

Well X-3

Well X-3 was converted to ESP in Dec 2014. The ESP string was completed with gas-separator system but the sand screen and shroud were not installed due to casing size limitation. Casing size in this well is 5.5-in which not allow to install the shroud. ESP motor size is 3.75-in while the casing ID is 3.9-in only. With this small clearance, the shroud cannot be run in this well. However, the well could produce up to 264 BLPD and 124 BOPD without any downhole problem. In July 2015, the ESP string was pulled-out due to end of rental time. ESP lifetime in this well is around 215-days.

Continuing the successful result of ESP trial above, thirteen (13) additional wells were then converted into ESP. The same ESP configuration which completed with sand screen and shroud were installed in nine (9) wells with 7-in casing production. While there are four (4) wells with 5.5-in casing production were not equipped with screen and shroud systems.

5. Result and Discussion

The wells that completed with sand screen and shrouded ESP systems showed good run lifetime. Five (5) ESPs are still running until today while four (4) ESPs were pulled-out.

Three (3) ESPs that were not equipped with sand screen system found pump problem due to proppant sand, while the other one (1) ESP is still running.

ESP Run Lifetime

Table-1 showing ESP run lifetime in thirteen (13) wells since the pump installed. ESPs that were completed with sand screen have performed well without any sand problem. Three of nine ESP's were pulled-out due MLE broken (well X-9 and well X-15) and tubing leak (well X-13); the ESP's were then rerun in the same wells and still running until now. One ESP in well X-14 were pulled-out due to high water cut (low oil production). The shortest lifetime was 39 days that shown in well X-15, however the ESP was then rerun and still running with run lifetime of 237-days.

Two of four ESP's that were not equipped with sand screen had been pulled-out and found proppant sand in the pumps (well X-5 and well X-6). One ESP (well X-10) found pump problem and suspected proppant sand was settling during ESP shut down due to surface electrical problem, however the ESP has been put back on operation after performing reverse circulation to flushing sand in the pump. Well X-6 had the shortest run lifetime of 30 days only. The ESP's were not rerun in those wells by considering that sand screen and shroud system cannot be installed due to casing size limitation.

Cumulative Oil Production

Oil production increased after the ESP installation. Cumulative oil gain production has been calculated by comparing oil production with ESP and oil production with gas lift. Total oil gain in 13 ESP wells are around 60.5 MBO. Table 2 shows oil gain from each wells.

Reducing Gas Lift Recycle

With this project, gas lift into ESP conversion, the needs of gas lift recycle has been reduced to about 3 MMSCFD in this field. By reducing the gas lift recycle volume, the number of operated compressor systems is also reducing. Figure 5 showing total gas lift recycle in SK field.

Next Strategy for 5.5-in Casing

Following the performance of sand screen and shroud system as described above, the challenges in ESP installation for 5.5-in casing shall be resolved thus the ESP conversion can be proceeded successfully in Telisa wells. A study has been conducted, to allow the screen and ESP system installation in 5.5-in casing. The sand screen will be installed below the ESP system and isolated with packer, as seen in Figure 6. This trial will be executed within this year. It is expected that there will be no downhole failures caused by proppant sand problem in the next installation.

6. Conclusion

As discussed above, it can be concluded:

- Integrated sand screen and shroud in the ESP system has presented good performance in handling proppant flowback problem in hydraulic fractured wells.
- While the ESP systems without sand screen were suffered from proppant sand which resulted in pump failure.
- The current sand screen and shroud system is only applicable in 7-in casing wells and is not applicable in 5.5-in casing wells.

7. Recommendation

A further study and trial of sand screen and ESP system in 5.5-in casing wells should be continued thus ESP conversion in Telisa wells with hydraulic fracturing can be sustained without any pump failure due to proppant sand problem.

8. Acknowledgement

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9. References

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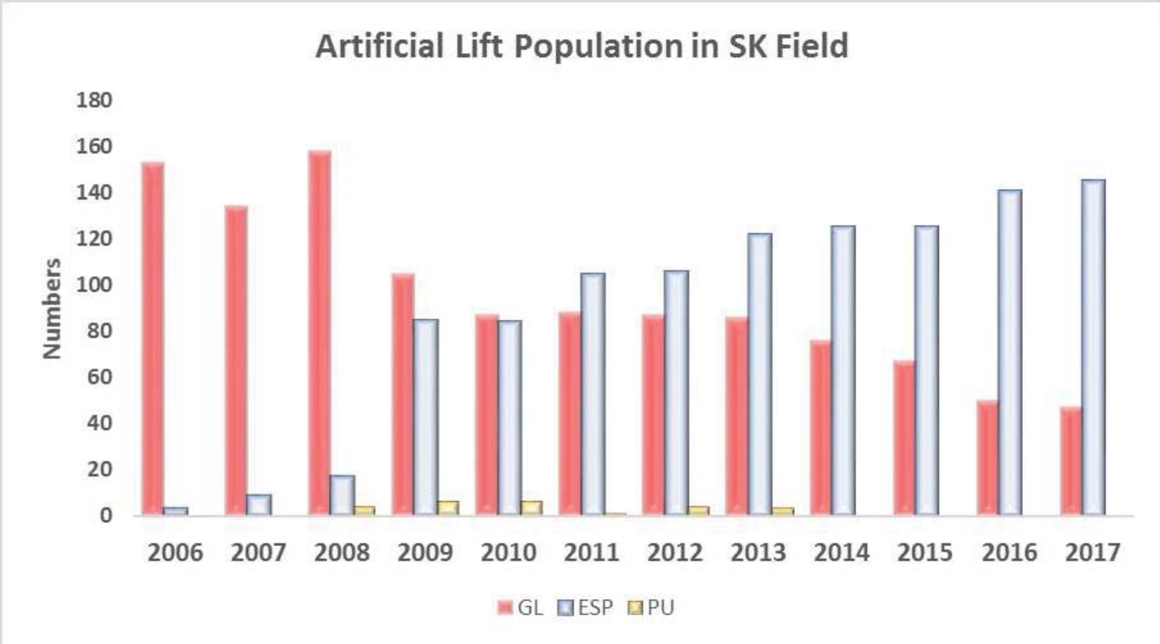

Figure 1. Artificial Lift Population in SK Field

Figure 2. Sand Frac (Proppant) found in Pump

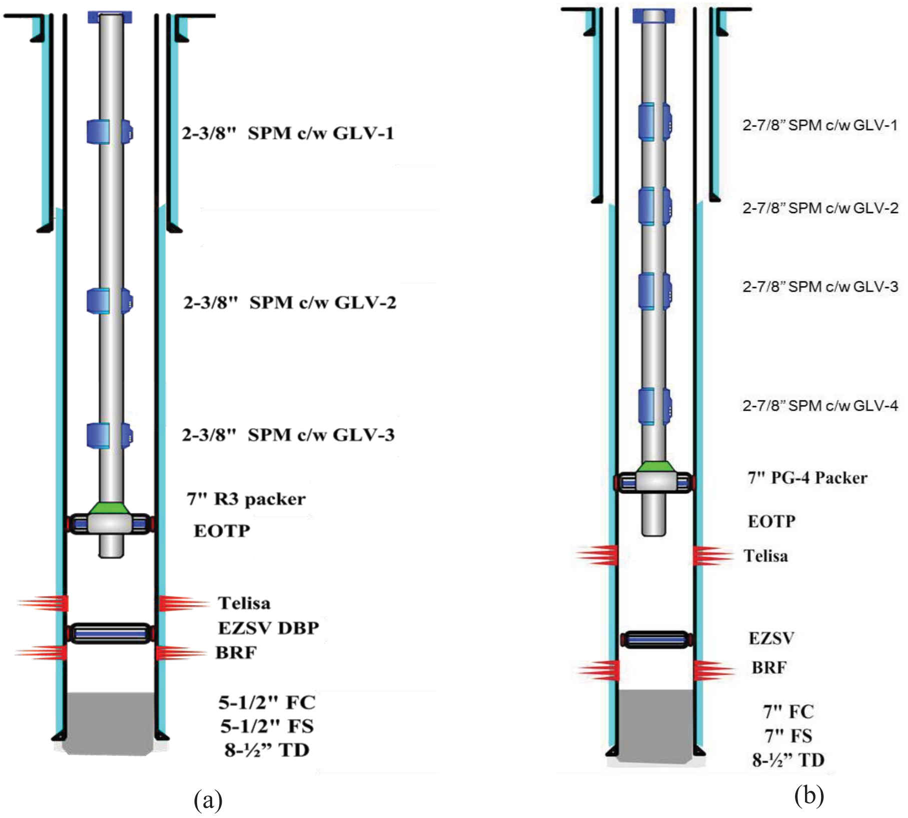

Figure 3. Typical of Initial Well Completion Design with Gas Lift: (a) 5.5-in Casing Size (b) 7-in Casing Size

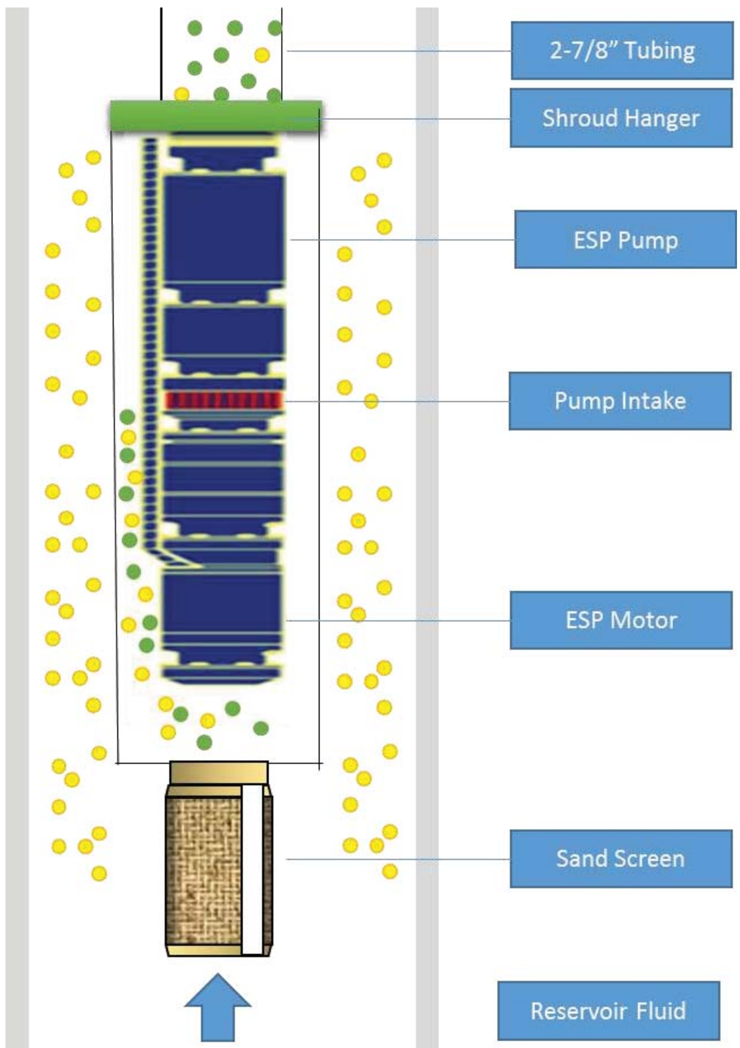

Figure 4. ESP Completion Design with Sand Screen and Shroud System

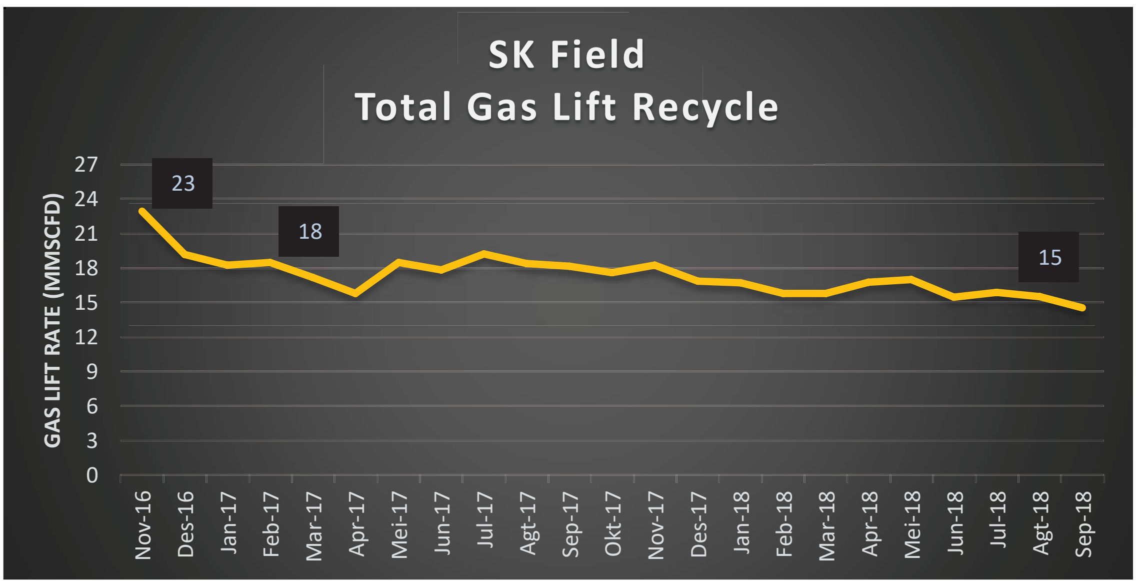

Figure 5. SK Field Total Gas Recycle

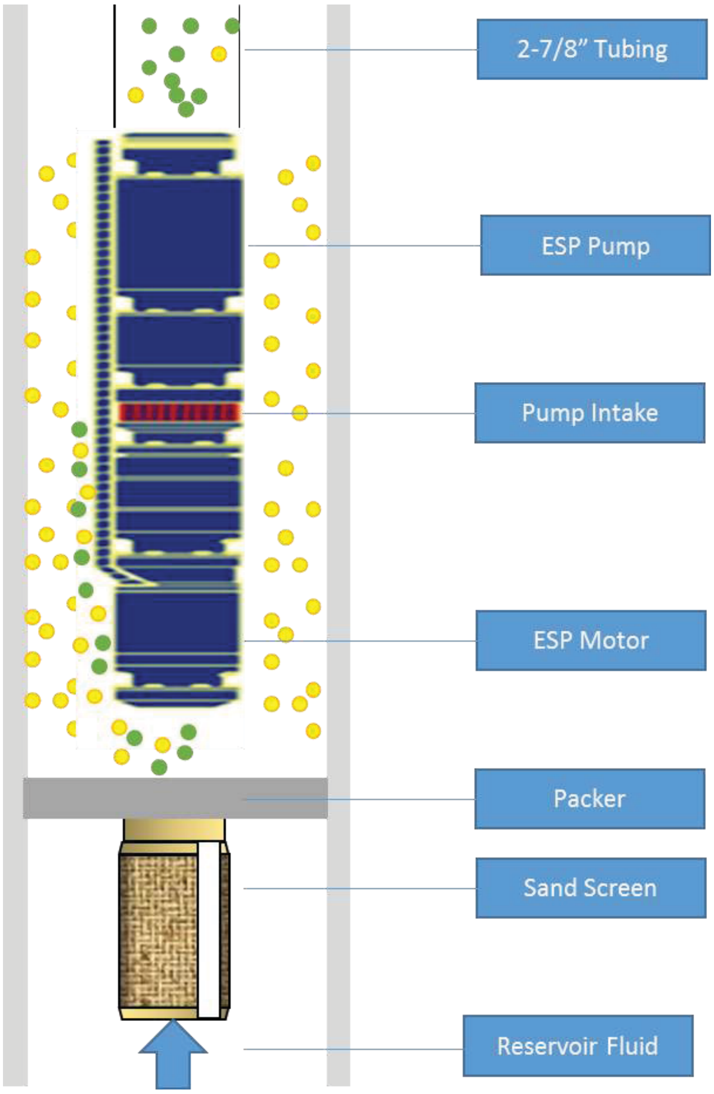

Figure 6. Proposed ESP Completion with Sand Screen in 5.5-in Casing

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Table 1. ESP Run Lifetime

Well Name	Formation	ESP Type	Sand Screen	Date of Installation	Down	Running, days	Pull Out Result/ Reason
Well X-3	TLS	60N 105 STG 45	Installed	6-Nov-16		663	
Well X-4	TLS	60N 105 STG 45	Installed	10-Nov-16		659	
Well X-5	TLS	60N 105 STG 45	No Screen	26-Nov-16	8-Mar-18	467	ESP Pump damage due to Frac Sand
Well X-6	TLS	60N 105 STG 45	No Screen	3-Dec-16	2-Jan-17	30	Fract Sand on ESP Pump
Well X-7	TLS	60N 105 STG 45	No Screen	7-Dec-16		632	
Well X-8	TLS	60N 105 STG 45	Installed	18-Dec-16		621	
Well X-9	TLS	60N 105 STG 45	Installed	22-Dec-16	28-Nov-17	341	MLE Broken
Well X-10	TLS	60N 105 STG 45	No Screen	25-Dec-16	2-Sep-17	251	Fract Sand on ESP Pump
Well X-11	TLS	800 116 STG 45	Installed	12-Jan-17		596	
Well X-12	TLS	60N 105 STG 45	Installed	4-Sep-17		361	
Well X-13	TLS	60N 105 STG 45	Installed	10-Sep-17	27-Mar-18	198	Tubing Leak
Well X-14	TLS	60N 105 STG 45	Installed	20-Sep-17	25-Dec-17	96	Recovered ESP due to high WC
Well X-15	TLS	60N 105 STG 45	Installed	24-Oct-17	2-Dec-17	39	MLE broken & protector dry

Table 2. ESP Oil Gain

No	Well Name	Oil Gain, MBO
1	**Well X-3**	6.0
2	**Well X-4**	8.3
3	**Well X-5**	3.7
4	**Well X-6**	0.0
5	**Well X-7**	14.9
6	**Well X-8**	-2.4
7	**Well X-9**	-9.6
8	**Well X-10**	16.4
9	**Well X-11**	0.4
10	**Well X-12**	1.1
11	**Well X-13**	1.6
12	**Well X-14**	-0.5
13	**Well X-15**	20.5
		60.5