



## Enhancing Oil Recovery in the E Intisar Field: Gas Lift Valve Design and Injection Optimization for Well E-65 103E - A Case Study

Nourden Mohamed Abdelsadeg \*

Chemical and Petroleum Engineering Department, Faculty of Engineering,  
Elmergib University, Alkumes, Libya

### تحسين استخراج النفط من حقل الانتصار: تصميم صمامات رفع الغاز وتعديل معدلات الحقن للبئر E-65-103E

نور الدين محمد عبد الصادق \*

قسم الهندسة الكيميائية والنفطية، كلية الهندسة، جامعة المرقب، الخمس، ليبيا

\*Corresponding author: [nmabdelsadeg@elmergib.edu.ly](mailto:nmabdelsadeg@elmergib.edu.ly)

Received: December 16, 2025

Accepted: March 03, 2026

Published: March 16, 2026

#### Abstract

The efficient extraction of hydrocarbons from oil and gas reservoirs is a critical aspect of the petroleum industry. As reservoirs mature, natural pressure declines, making it increasingly challenging to recover the desired production rates. Artificial lift systems play an important role in enhancing production rates by providing the necessary energy to lift fluids to the surface. This paper focus on type of artificial lift which is Gas lift. Gas lift is widely used artificial lift technique that employs compressed gas injected downhole the the well tube or casing to reduce the hydrostatic pressure of the wellbore, thereby facilitating fluid flow to the surface. In this paper EIntisar Field Well E-65-103E is selected for the study. The main task in this study is to redesign a gas lift system for well E-65, a case study by using PIPESIM software.

The main points obtained and determined using the software are number of gas lift valves needed to lift the wells up, also the depth of these valves distributed through the tubing and space between them. In addition to this, the amount of gas injected daily through these valves from casing to tubing. Finally, internal flow performance curves versus vertical lift performance curves for well E-65 were determined before and after the gas lift redesign as an indicator of increased productivity, as the liquid production rate before the gas lift redesign was 554 STB/d, The redesign process contributed to the injection of appropriate amounts of gas into the hole, which increased the liquid production rate to 688 STB/d through simulation using the PIPESIM program, thus improving the oil production rate by about 19.5% compared to the first design.

**Keywords:** Hydrocarbon Extraction, Artificial Left, Gas Left Design, Production optimization, PIPESIM Software.

#### الملخص

إن الاستخراج الفعال للهيدروكربونات من خزانات النفط والغاز يعدّ أمرًا أساسيًا لقطاع صناعة النفط. مع نضوج الخزانات، يؤدي انخفاض الضغط الطبيعي إلى تعقيد الحفاظ على معدلات الإنتاج المثلى. تلعب أنظمة الرفع الاصطناعي دورًا محوريًا في تعزيز الإنتاج من خلال توفير الطاقة اللازمة لنقل السوائل إلى السطح. تقدم هذه الورقة دراسة شاملة لأساليب تصميم أنظمة الرفع الاصطناعي، مع تركيز خاص على أنظمة الرفع بالغاز.

تعتبر تقنية الرفع بالغاز واحدة من الأساليب الشائعة التي تستخدم الغاز المضغوط المحقون في عمق البئر لتقليل الضغط الهيدروستاتيكي في عمود البئر، مما يسهل تدفق السوائل إلى السطح. تختار هذه الدراسة بئر E-Intisar Field Well E-65-103E كحالة دراسية وتصميم نظام الرفع بالغاز تم باستخدام برنامج PIPESIM. تحدد عملية التصميم المعايير الرئيسية، بما في ذلك عدد وموقع صمامات الرفع بالغاز ومعدلات حقن الغاز اليومية المطلوبة من السطح إلى الأنابيب. يتم تقييم فعالية إعادة التصميم من خلال مقارنة منحنيات الأداء لتدفق السوائل الداخلية مع منحنيات الأداء العمودي للرفع لبئر

E-65 قبل وبعد عملية إعادة التصميم. تم تسجيل الإنتاج السائل الأولي بمعدل STB/d554 ، والذي ارتفع إلى 688 بعد إعادة التصميم، مما يعكس تحسناً ملحوظاً بنسبة حوالي 19.5% في إنتاج النفط. تؤكد هذه الدراسة على أهمية تصميم أنظمة الرفع بالغاز المحسن في تعزيز إنتاج السوائل من آبار النفط.

**الكلمات المفتاحية:** استخراج الهيدروكربونات، الرفع الاصطناعي، تصميم الرفع بالغاز، تحسين الإنتاج، برنامج PIPESIM.

## 1.Introduction

### 1.1.Background

The demand for hydrocarbons is increasing worldwide. In order to extract hydrocarbons from reservoirs , companies tries all its skills and effort to extract more oil and gas . Initially, reservoir are at high natural pressure which facilitates the natural flow of fluids to the surface, a process known as primary recovery. However, with time reservoirs age and reservoir pressure declines , this leads to decreased production rates which means less oil and gas reaches the surface. To offset this decline, the need for means of maintain the pressure, artificial lift systems have been developed. These systems are very important to keep the efficient production of fluids from wells, thus extending the productive life of oil and gas fields [1].

One of the most efficient technique of artificial lift is the gas lift. This method simply inject gas at high pressure to the stream of oil in the well tubing or/and casing to reduce the hydrostatic pressure in a wellbore, enabling oil and gas to flow to the surface [2]. The gas lift methods ( continuous or intermittent) are characterized by their ability to manage varying reservoir conditions, making them suitable for different types of wells, including those with high viscosity fluids or high gas to liquid ratios. Despite its wide use, optimizing gas lift design remains a challenge. There are number of factors influencing the performance of gas lift . These include the spacing and number of gas lift valves, injection pressures, and reservoir fluids properties [3].

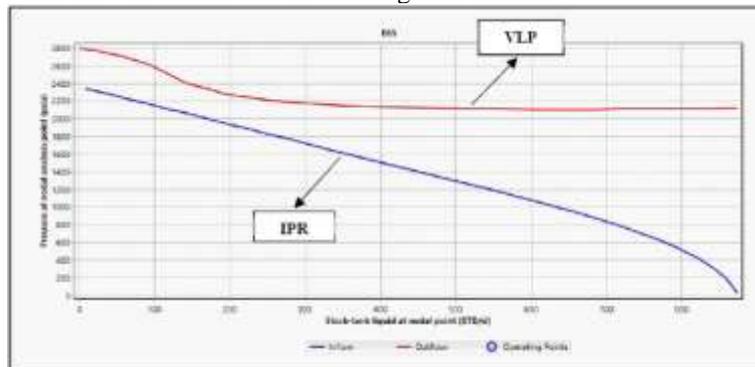
The Intisar Field in Libya, particularly Well E-65-103E, serves as a relevant case study for investigating gas lift design improvements. Well E-65 needs re-evaluation to its current current performance, which reflects the effects of declining reservoir pressure and inadequate previous configurations of the gas lift system. Using PIPESIM software, this research aims to model and analyze the dynamics of the gas lift process, ultimately seeking to identify optimal configurations for gas lift valves that will improve production efficiency [4].

The main goals of this study are to ascertain the most effective number and positioning of gas lift valves while determining suitable gas injection rates. The research will assess how these modifications affect the inflow performance of Well E-65-103E, comparing key performance metrics before and after the installation of the redesigned gas lift system [5].

The importance of this approach not only to increase oil and gas production but to also increase the life of oil fields and thereby having better economic returns.

### 1.2. Problem Statement

An oil reservoir is usually produce oil and gas by natural flow, that means the pressure at well bottom is sufficient to overcome the sum of pressure losses occurring along the flow path to the separator, When the condition is no longer met due to decrease in bottom hole pressure, or pressure losses in the well become too great, the natural flow stops and the well dies as illustrated in figure 1.



**Figure 1:** Inflow vs. Outflow Curves Before Gas Lift For Well E-65-103E

### 1.3. Objectives

- The primary objective of this study is to optimize the production of oil or gas from well E-65 by using gas injected into the wellbore to reduce the hydrostatic pressure and increase the flow of fluids.
- Using advanced software's like PIPESIM to Improve hydrocarbons production by selecting and designing number of gas lift valves needed to lift the production up, also the depth of these valves

distributed through the tubing and space between them. In addition to this, the amount of gas injected daily through these valves from casing to tubing.

- Increasing productivity by determining Inflow performance relationship curve versus vertical lift performance curve for E-65 well before and after utilizing gas lift design .

#### 1.4. Study Significance

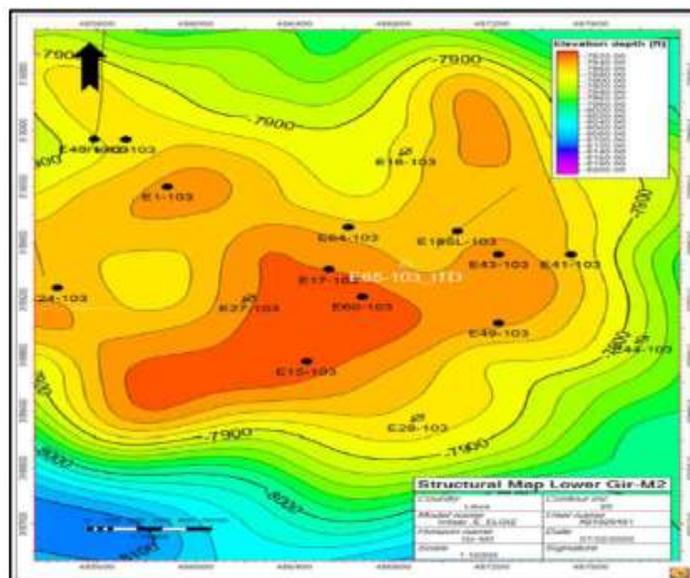
As gas lift techniques continue to evolve, insights from this research can contribute significantly to the field of petroleum engineering in Libyan oil fields, providing a framework for Libyan companies and major oil producers to optimize their production. Moreover, improving the efficiency of hydrocarbon extraction processes is of paramount importance.

## 2. Material and methods

### 2.1. Study Area Description and data collected

#### 2.1.1. Background of Intisar Field

The field is located in southeastern part of Sirte Basin in Libya approximately 260 km to the south west of Benghazi for Zueitina Oil Company, Geographically it is located between latitudes 31" and 32" north, and between longitudes 21 and 22° east. The field have (37 wells) producing oil, (3 wells) producing by ESP, (34 wells) producing by Gas lift, the Source of gas injection from field 103E. (Agip gas), and no wells produce by natural flow [6].



**Figure 2:** E-65-103E Location Map on Intisar Top Structure Map (Zueitina Oil Company data base)

#### 2.1.2. Reservoir – Intisar "E"

Intisar oil field consist of seven separate producing reservoirs, having reservoir on the top and reservoirs to the down labelled as El-Giza (A), El-Giza (B), Upper Gir (A), Upper Gir (B), Upper Gir (C), Lower Gir and Shoal. All reservoirs are carbonates, particularly limestone. Upper Girs (A), (B) and (C) are the major reservoirs of the 103E field. The total Original Oil in Place (OOIP) is 291 MMSTB which constitute about 66% of the total field oil in place of 442 MMSTB. The hydrocarbon bearing zones have an average thickness of 55 ft in Gir (A), 50 ft in Gir (B), and 25 ft in Gir (C). These reservoirs are stacking on top of each other and separated by 100-150 ft aquifers and thin non-communicable barriers. From the previous review, it has been noted that the Gir (A) is the major reservoir in Intisar 103E field this study focus on Gir (A) reservoir [6].

#### 2.1.3. Gir (A) Reservoir

The Gir A is limestone with a rather high porosity and low permeability, the oil system is medium to light and is highly under saturated [6]. The Reservoir Data of Gir (A) can be summarized in table (1).

**Table 1** Reservoir Data of Gir (A)  
**Reservoir Gir (A): Data Summary**

Reservoir		
Formation Depth,(D)	8172	ft
Avg. Net Pay, (h)	55	ft
Initial Pressure, (P.)	3686	Psia
Current Psia	2358	Psia
Reservoir Temperature, (T)	216	F
Rock Properties		
Avg. Porosity, ( $\phi$ )	15.2	%
Initial Water Saturation, (S)	32	%
Avg. Permeability, (kavg)	2	Md
Fluid Properties		
Saturation Pressure, (P)	1500	Psia
Saturation, (GOR)	616	SCF/STB
FVF@ Initial Pressure, (Bo)	1.49	RB/STB
Oil Viscosity @ Initial Pressure	0.46	cp
Oil Gravity, (API)	39.5	API

#### 2.1.4. Well (E-65)

The field data for this well have been brought for analysis in this study. The well is being proposed to put under gas lift optimization. PVT data, IPR entry data, Downhole data (deviation survey and equipment) and well testing data (BHFP and PI) for the well are provided [6]. These data are arranged separately based on the PIPESIM simulator input requirement and all units will be field unit. This is to give better understanding on correlation and matching with reality.

**Table 2** PVT Data for well E-65.

Parameters	Quantity	Unites
Solution GOR	616	scf/stb
Oil Gravity (API)	39.5	API
Gas gravity	0.8	scf/stb
Water salinity	198,000	ppm
Bubble point pressure	1500	psig
Oil FVF	1.49	Stb/bbl
Oil Viscosity	0.46	cp

**Table 3** IPR data for well E-65

Parameters	Quantity	Unites
Reservoir pressure	2358	psig
Reservoir temperature	216	Deg.F
Water cut	4	%

**Table 4** Trajectory description data for well E-65

Measured depth (MD), ft	True vertical depth (TVD), ft
0	0
8970	8970

**Table 5** Downhole equipment for well E-65

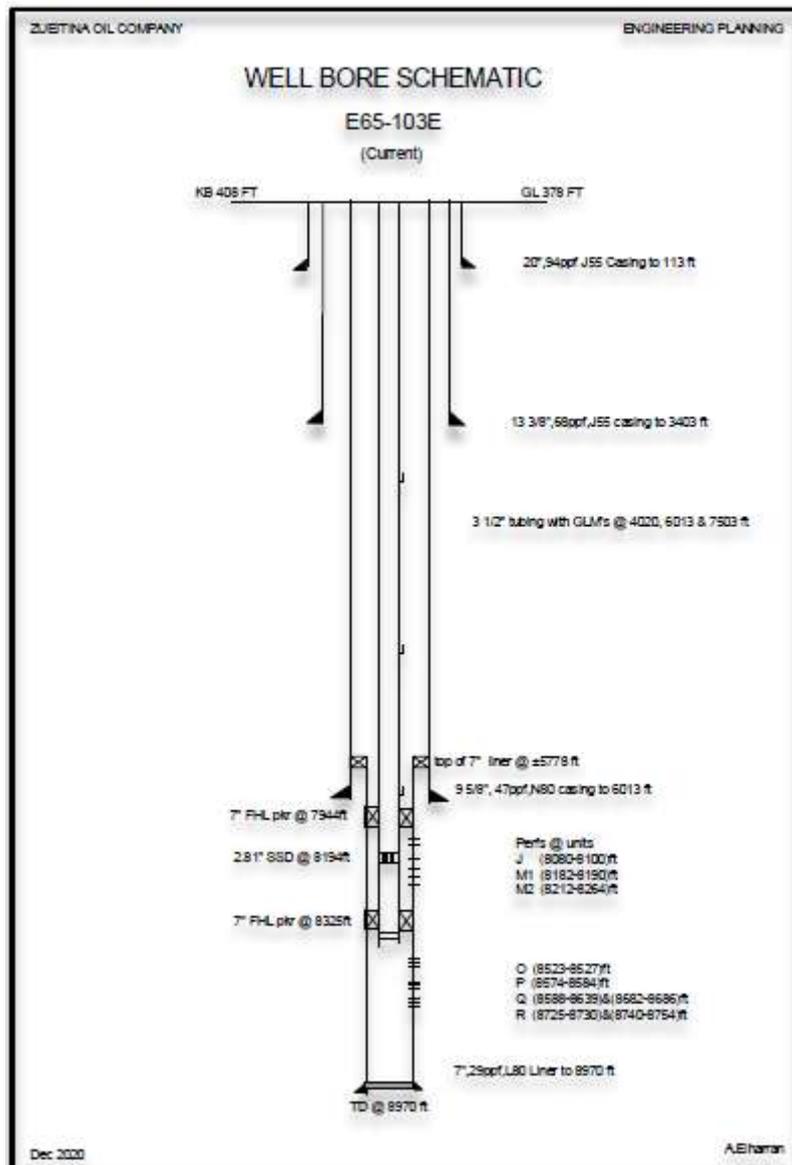
Tubing dimensions		Liner dimensions	
OD, inches	Depth, ft	OD, inches	Depth, ft
3.5	8335	7	8970

**Table 6** Well data and well test data for well E-65

Well test data	9 - Sep - 2023	Units
Gross	554	bbl/d
WC	4	%
BWPD	22	bbl/d
BOPD	532	bbl/d
Gas	238	scf/d
GOR	448	scf/bbl
PI	0.46	stb/day/psi
SBHP	2358	psig
FBHP	1221.29	psig
Tubing head pressure	220	psig
Casing injection pressure	600	psig
Choke	F.O	---
API	N.A	---
Salinity	198,000	Ppm
AMPS	G/L	---
Gas lift gas	3023	---
Dynamic fluid level	G/L	ft

**Table 7** Well casing configuration

Type casing	Size (in)	Weight (lb/ft)	Grade	Setting depth
Conductor	20	94	J-55	113
Surface	13 3/8	68	J-55	3403
Production	9 5/8	47	N-80	6013
Liner	7	29	L-80	8970
Tubing	3 1/2	9.3	L-80	8335



**Figure 3:** E-65-103E Wellbore schematic

## 2.2. Overview to PIPESIM software

PIPESIM is a powerful engineering tool widely used for gas lift design [7]. PIPESIM is developed by Schlumberger, and it is used for a steady-state multiphase flow simulator specifically designed for oil and gas production systems [8]. The software capabilities include the following:

1. Modeling complex wellbore configurations: PIPESIM can handle vertical, horizontal, and deviated wells, as well as complex completions with various types of gas lift mandrels and valves [9].
2. Simulating multiphase flow phenomena: The software accurately models the interaction between gas and liquid phases, considering factors like bubble size, slip velocity, and flow regime transitions.
3. Optimizing gas lift injection parameters: determining the optimal gas injection rate, pressure, and valve settings in order to increase well production and decrease the consumption of gas [8][9].
4. Sensitivity analysis: The software allows for performing sensitivity studies to assess the impact of various parameters on system performance, enabling engineers to identify critical factors and optimize design choices [8][9].
5. Visualization tools: PIPESIM provides graphical representations of flow profiles, pressure drops, and production rates, facilitating a clear understanding of system behavior [9].

### 2.3. Steps involved in the redesign of well E-65-103E using PIPESIM model

- Run PIPESIM software and main screen (workspace) is as in figure 4 .

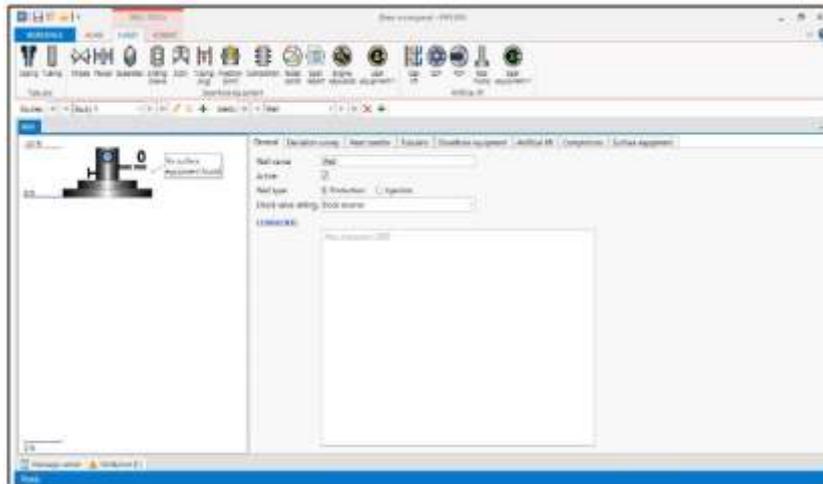


Figure 4: Main workspace window of PIPESIM software

- From the main workspace press icon tubulars to input the following casing and tubing data: grade, depth, outside diameter and weight as shown in figure 5.

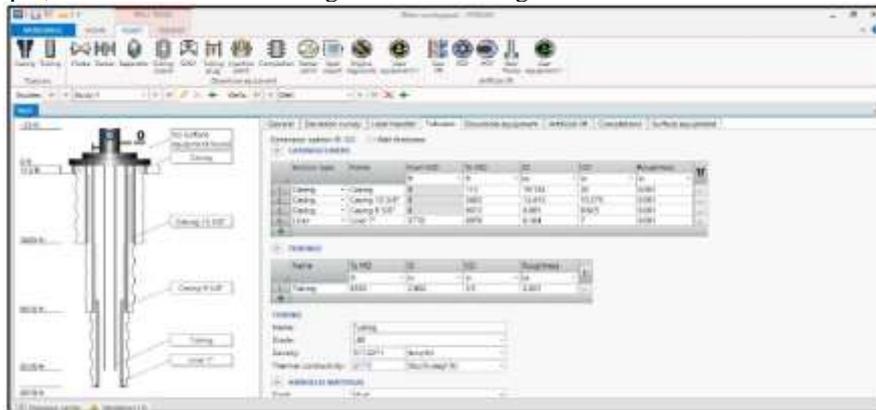


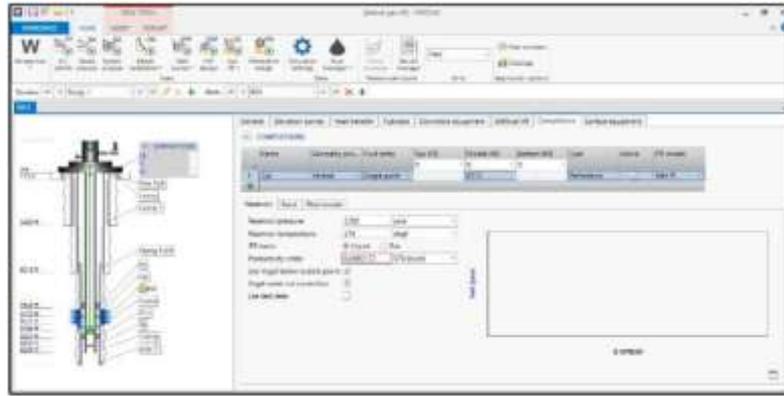
Figure 5: Tubulars input data screen

- From the main workspace, press downhole and input the following data: depth of first packer, second packer, tubing plug, and sliding sleeve as shown in figure 6.



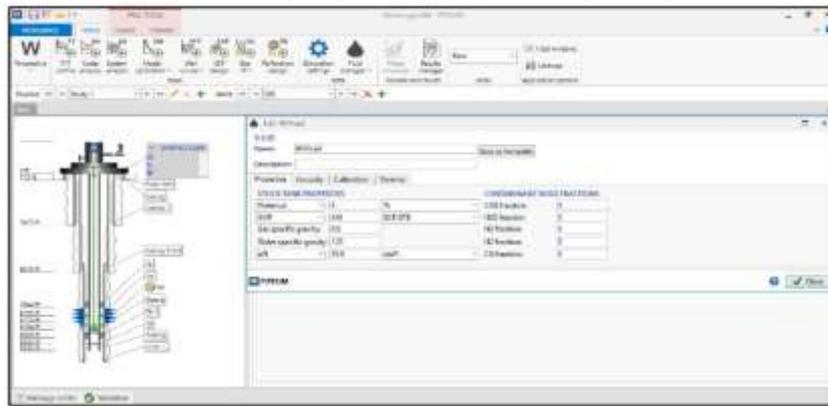
Figure 6: Downhole input data screen

- From the main workspace press completions then input the middle of perforation depth and then input reservoir pressure, reservoir temperature and productivity index of the well as shown in figure 7.



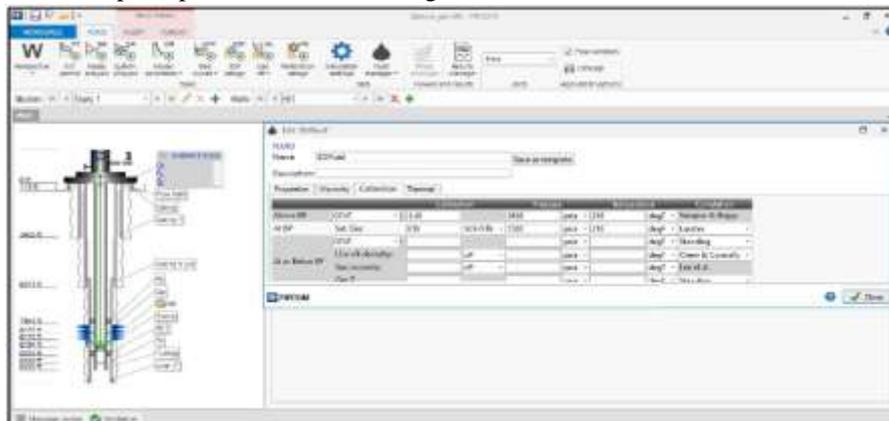
**Figure 7:** Completions input data screen

- Then, from the main workspace press fluid model and the input the stock tank properties following data : Gas oil ratio, water cut, gas specific gravity, water specific gravity, and API.



**Figure 8:** Stock tank properties input data screen

- Then the PVT fluid data is entered by Pressing fluid model calibration. These data are oil formation volume factor, reservoir temperature, initial reservoir pressure ,solution gas oil ration and bubble point pressure as shown in figure 9.



**Figure 9:** Fluid model calibration input data screen

- Now the design of gas lift data is entered, which include : the boundary conditions data (production outlet pressure, reservoir pressure, reservoir temperature , water cut and gas oil ration) , and the injection parameters (operating injection pressure, Gas specific gravity, Target injection rate, Surface injection temperature, surface injection rate range (mmscf/d), and surface injection pressure)[10]. Then click run as shown in figure 10.

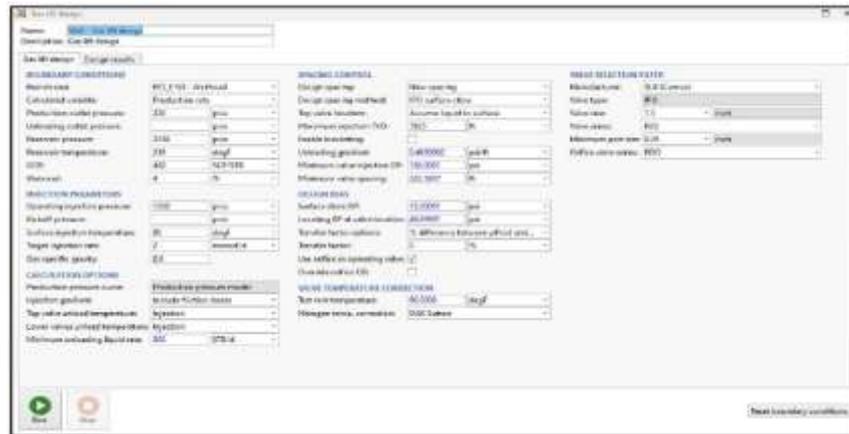


Figure 10: Gas lift design data input screen

- Final step press nodal analysis and input the outlet pressure , then click run. After that result are extrapolated as shown in the results section.

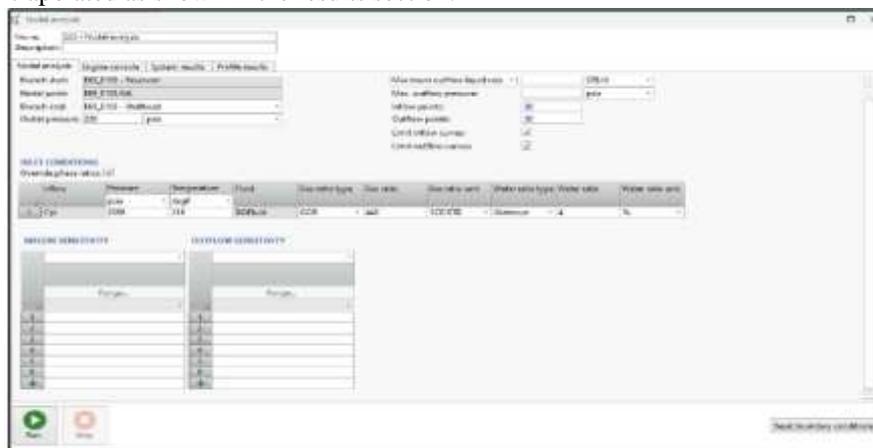


Figure 11: Nodal analysis data input screen

### 3. Results and discussion

#### 3.1. Inflow Performance Relationship curve:

Figure 12 describes the pressure drop as a function of production rate which is referred to the flow performance relationship (IPR) for well E-65, where drawdown is defined as the difference between static and flowing pressure at the bottom of the well. First, the internal flow performance relationship curve exhibit to straight-line method until the bubble pressure is reached, after which the gas begins to be released (saturated Reservoir) and the IPR study becomes subject to the laws of the Vogel method.

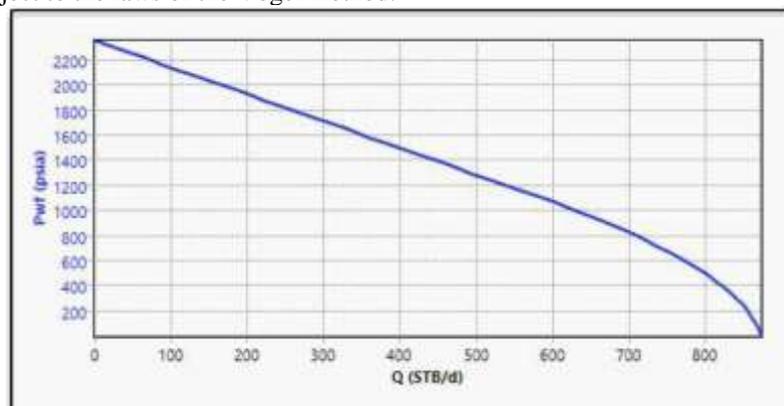


Figure 12: Inflow Performance Relationship curve for well E-65.

### 3.2. Inflow versus outflow curves before gas lift:

Input parameters in PIPESIM gives a production profile, with no artificial lift as illustrated in figure 13. As it can be seen that the well E-65 is unable to produce naturally because VLP does not intersect with IPR [11].

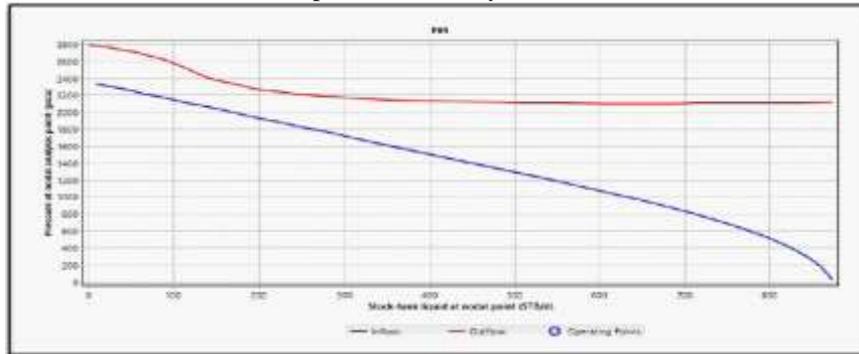


Figure 13: Inflow versus outflow curves before gas lift for well E-65.

### 3.3. Gas lift performance curve:

Performance curves give us a plot of oil produced versus gas injected. The optimal economic gas injection rate is often found to the left of the maximum production rate. The gas lift performance curve shown in Figure 14 shows an increase in the oil production rate with respect to the trend of the gas lift injection rate curve. Initially, when a gas injection rate of 1mmscf/d is applied, the oil production rate is 672 STB/d. The optimal injection rate is 2mmscf/d with a production rate of 688 STB/d. The rate of oil production increases as the gas injection rate increases to the point of reaching a certain limit of gas injection, and thus the curve decreases due to the presence of large quantities of gas in the pipe, which ultimately reduces the production rate due to the increase in GOR, which causes gas circulation. All tables should be inserted in the main text article at its appropriate place [11].

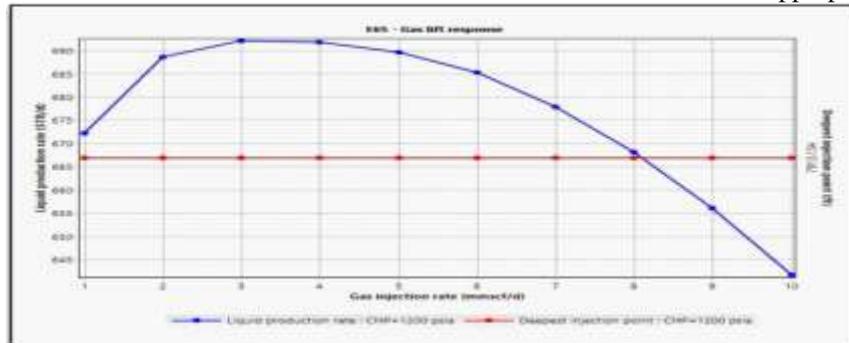


Figure 14: Gas lift performance curve from well E-65

### 3.4. Positioning of valves:

After designing the gas lift system using the PIPESIM program, by entering well data. The graph shows pressure versus depth as shown in the following figure 15. The following figure shows the depth of the valves, the opening and closing pressures of the valves, and the pressure gradient flowing in the pipe. The design shows four IPO valves at optimally designed injection pressures and depths. And another orifice valve (operating valve) at a depth of 7,924 feet with a pressure of 1,497 psi and a suitable gas temperature of 214°F to prevent hydrate problems.

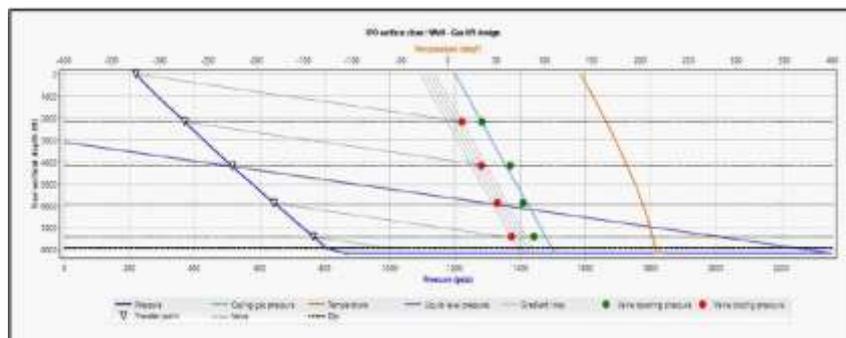


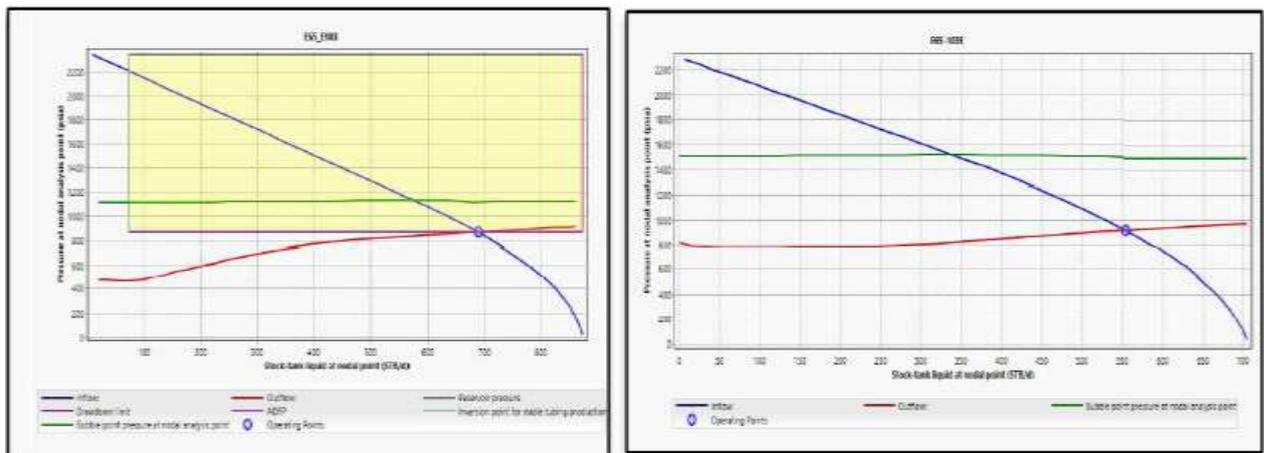
Figure 15: Position of gas lift valves for well E-65.

**Table 8** Well E-65 design results

MD	Type	Injection pressure	Production pressure	Actual Unloading gas rate	Actual Unloading liquid rate	Opening pressure	Closing pressure	Production Temperature	Valve temperature
ft		psia	psia	Mmscf/d	STB/d	psia	psia	degF	degF
2174.92	IPO	1281.34	369.86	1.33	308.38	1281.34	1220.97	164.86	158.18
4188.84	IPO	1356.33	515.58	2.11	343.39	1368.46	1280.96	186.78	181.30
5897.01	IPO	1420.25	644.59	2.14	330.94	1408.23	1329.88	202.46	198.52
7418.84	IPO	1477.61	764.46	2.20	317.37	1441.72	1372.24	212.98	211.23
7924.00	Orifice	1496.83	805.31	2.0	688.59	-	-	220.64	214.70
<b>Casing head pressure</b>						1200 psia			
<b>Total injection gas rate</b>						2 mmscf/d			
<b>Liquid flow rate at outlet</b>						688.5991 STB/d			
<b>DIP</b>						7924 ft			
<b>Reservoir pressure</b>						2358 psia			

**3.4. Comparison between PIPESIM design & first design**

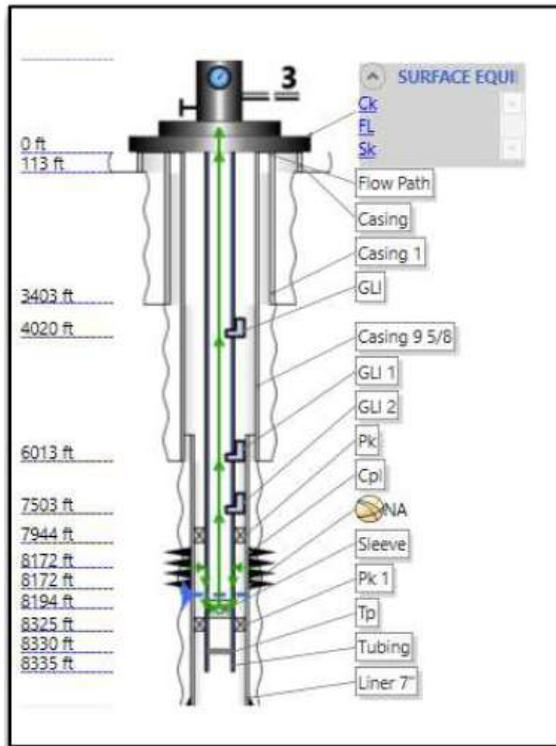
From Figure (16a), the inflow performance relationship in well E-65 is shown through simulation using the PIPESIM program, the operating point of the well can be seen at the intersection between the inflow performance relationship (IPR) curve and the vertical lift performance (VLP) curve, where the Bottom hole flowing pressure is 862 psi and liquid flow rate 688 STB/d, and from Figure (16b) designed by Zueitina Oil Company is the value of Bottom hole flowing pressure 917 psi and liquid flow rate 554 STB/d. The redesign contributed to injecting appropriate amounts of gas into the wellbore which led to its mixing with the producing fluids and reducing the density of the fluids to facilitate the process of raising the oil to the surface. Therefore, the oil production rate improved by approximately 19.5% compared to the first design.



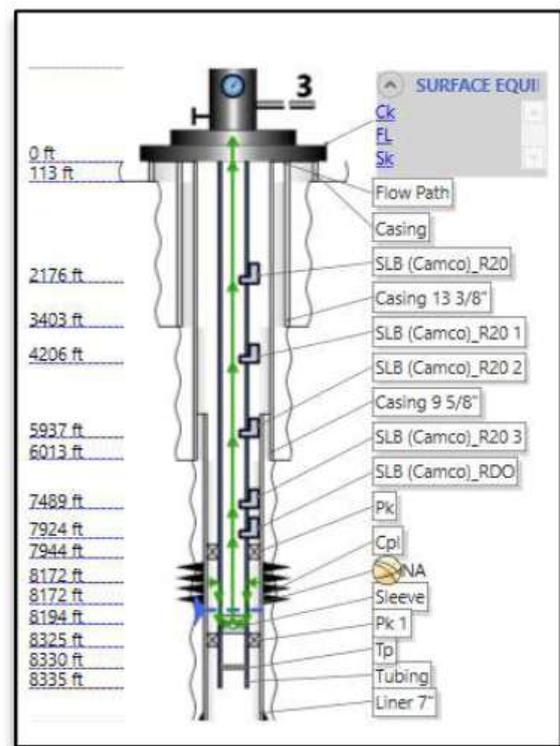
**Figure 16a:** After Redesign Inflow vs. Outflow curves **Figure 16b:** Before Redesign Inflow vs. Outflow curves

Figure (17 a). shows the first design of the gas lift used by Zueitina Company, and shows the equipment located below the surface (depths of casings, depth of pipe, depths of lift valves, packer and SSD) and the depth of the producing zone. The number of lift valves is (3 valves), and the surface injection pressure is 600 psia, so the liquid production rate is 554 STB/day.

Figure (17b). shows the gas lift design used by PIPESIM Software, show subsurface equipment (casing depths, tube depth, lift valves depths, packer and SSD) and the depth the producing zone. By redesigning the gas lift, the number of valves that were designed using the PIPESIM program became (5 valves), and the production liquid rate increased to (688 STB/Day) An increase of approximately 19% equivalent (134 STB/day) and 1200 psia surface injection pressure, compared to the first design. for well E-65.



**Figure 17a:** Original E-65 wellbore diagram



**Figure 17b:** After redesign E-65 wellbore diagram

## Conclusion

The study can be summarized as follows:

- Continuous gas lift Installation is proper solution to lift the (E-65) well, due to the low permeability and high water cut rate in this well by 4% which in turn increasing Pwf to approach the reservoir pressure, which in turn leads to a sharp decline in oil production.
- By Applying the gas lift design for well (E-65), an observed liquid production rate of 688 STB/day is obtained using PIPESIM software by instruction IPR with VLP curve.
- Optimum gas injection rate for well (E-65) are 3 MMscf/day, any additional gas injection will reduce the rate of oil production due to increased friction and the movement of gas faster than oil.
- The daily gas injection rate for well (E-65) is 1 to 2 million barrels per day, and any higher value will only result in a slight increase in oil production.
- Only five valves, as result of gas lift design by PIPESIM, are needed to unloading the well selected for this study (E-65).
- The study concluded that oil production from well E-65 can be increased if the Zueitina oil company adopt the same steps as stated in this study.

## Compliance with ethical standards

### Disclosure of conflict of interest

The author(s) declare that they have no conflict of interest.

## Reference

- [1] Schlumberger. *Gas Lift Design and Technology*. Chevron Main Pass 313 Optimization Project 09/12/2021.
- [2] Artificial Lift Manual Part 1. "The EP Business Model Approach to Artificial Lift Systems". SIPM EPD/41 Dec. 1993.
- [3] American Petroleum Institute. (1994). *API Gas Lift Manual*, Book 6 of the Vocational Training Series. Exploration and Production Department, Washington, DC.
- [4] PIPESIM. (2022). *Artificial Lift Design and Optimization, Version 2022.1*.
- [5] Schlumberger. *Gas Lift Design and Technology*, 1999.

- [6] Zueitina Oil Company. (2026). *Oil Fields*. Retrieved from <https://www.zueitina.com.ly/en/sites-oil-fields>
- [7] Schlumberger. (2023). *PIPESIM: Steady-State Multiphase Flow Simulator*. Retrieved from [\[https://www.slb.com/software/pipesim\]](https://www.slb.com/software/pipesim).
- [8] Schlumberger. (2023). *Gas Lift Design and Applications*. Retrieved from [\[https://www.slb.com/resource-center/gas-lift\]](https://www.slb.com/resource-center/gas-lift).
- [9] Schlumberger. (2023). *Visualization Tools in PIPESIM: Enhancing Flow Analysis*. Retrieved from [\[https://www.slb.com/software/pipesim/visualization\]](https://www.slb.com/software/pipesim/visualization).
- [10] Services company, 2007. 10. Shell artificial lift manual part 2A - gas lift design guide - report EP93-2702-December 1993.
- [11] Decker K.L. Gas Lift Valve Performance Testhg. March 1993. SPE 25444

---

**Disclaimer/Publisher's Note:** The statements, opinions, and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of **AJAPAS** and/or the editor(s). **AJAPAS** and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions, or products referred to in the content.