

# Implementation Gas Lift Selection Technique and Design in the Wafa Field of Ghadamis Basin, West Libya

E. I. Fandi, E. A. Alfandi, M. A. Alrabib

**Abstract**—Implementing of a continues flow gas lift system for one vertical oil well producer in Wafa field was investigated under five reservoir pressures and their dependent parameters. Well 03 producers were responded positively to the gas lift system despite of the high well head operating pressures. However, the flowing bottom hole pressures were reduced by a ratio from 6 to 33 % in the case A3 for example, for the design runs conducted under the existing operating conditions for years 2003, 2006 and 2009. This reduction in FBHP has increased the production rate by a ratio from 12 to 22.5%. The results indicated that continues flow gas lift system is a good candidate as an artificial lift system to be considered for the one vertical producer covered by this study. Most significantly, timing for artificial lift by a gas lift system for this field is highly dependent on the amount of gas available at the time of implementation because of the high gas production rate from the top of the reservoir.

**Keywords**—Gas lift, Wafa field, Ghadamis Basin, Artificial lift, Libya.

## I. INTRODUCTION

THE Wafa field is a gas-condensates reservoir with an oil rim located about 600km southwest of Tripoli in the NC169A Concession, (Fig. 1) along the Libyan-Algerian border, east of Algerian field of Alrar Wafa is a stratigraphic trap formed by F3 sandstone member of the Aouinet Ouenine Formation of Middle Devonian. Wafa is mainly a gas condensate reservoir with an average gross pay thickness of 100 ft underlain down dip by a small oil leg 40°API, 62 ft thick [1], [3].

Wafa field is subdivided into two areas, northern and southern. With regards to the depositional model, the general feeling is that all the gravity flows coming from the Tihemboka element deposited the bulk of their load in the Algerian sector and those them divided in at least two branches giving origin respectively to the Wafa North and Wafa South. While the southern part of Wafa was discovered in 1964 by the well D1 drilled by Shell the northern one, which is the largest, was discovered by Sirte Oil Company in

1991 with well A1. This sandstone wedge pinches out towards south and east; northwards the closure is by aquifer After A1

Sirte Oil Company started from 1991 to 1994 and extensive appraisal campaign with the drilling of additional 7 wells, A2 to A8.

The amount of the measured maximum liquid drop out (as per A8 well testing results), indicating a nature of lean gas condensate fluid. A negligible composition variation with depth has been observed for the deeper wells. The average gas gravity is about 0.80 (air=1) and the condensate specific gravity is about 65° API [9].

After the last reservoir study (Western Libya Gas Project) [6], where the development strategy was defined, four more appraisal wells (A9 to A12) were drilled by Agip Gas BV in the period 1998-1999 [8].

The development phase, started at the end of 2001, planned the work over of the existing 8 wells (A1-A9) and the drilling of additional 29 wells (A13-A41) for a total of 37 wells. At the time being three development wells have been added on the Libyan Algerian border (A42-A44) to reduce the impact of the production regime in AlRar [4].

The formation of the reservoir was essentially a sandstone of the Middle Devonian age [10] situated in the F3 level Aouinet Ouenine “B” Formation, hydraulically connected with the Algerian Al Rar field. The formation was divided into four main levels characterized as follows:

1. The “upper” layer very good petrophysical parameters;
2. The “medium” layer good petrophysical parameters;
3. The “lower” layer not productive;
4. The “shaly” layer: completely tight.

The net pay considered in the interpretations was the sum of the middle and upper layer thicknesses limited by GOC upward and by the OWC downward [2], [4].

The present study, originally titled “Wafa Field –Oil Zone – Reservoir Model Revision and Well Productivity study”, was commissioned by Agip Gas in February 2003 and had initially to be focused on the oil zone due to the first unexpected results of the oil wells ENI Milan (TEOP and GIAC Dept) was involved with the main objectives of:

- Evaluating all the data recorded during the first phase of the development plan with particular attention to the north zone (A39, originally planned as a gas well, found a deeper and lower permeability reservoir interval).
- Analyzing the well testing results (well A06 not producing, A03 producing with high GOR and A18 with low FTHP).

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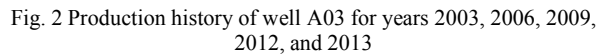
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- To achieve the above main target the reservoir model was completely revised in both geological (reservoir top, layering and petro-properties description) and dynamical (model gridding, well productivity and VLP) properties to better represent the behaviors of the full Field (gas and oil zone). The work has been done in the period February-November 2003[7].



To predict timing for the artificial lift system, sensitivity runs were conducted using Wellflo software package developed by Edinburgh Petroleum Services 2006 EPS Ltd.

The A3 was a vertical well. The reservoir was drilled through with a 8½” bit, completed with a 7” casing and 4 1/2” string production. The interval was perforated in overbalance condition from 8630 ft KB TVD to 8655ft KBTV D using a 4 1/2” HSD casing guns with 12 SPF. From side the production history (Fig. 2).



In a depletion drive reservoir, natural flow period is highly dependent on the reservoir pressure, size of the gas cap and the amount of dissolved gas. So, it is anticipated that flow rate will decline until the economic limit is reached.

| Years | Liquid Rate Before<br>lifting (STB/day) | FBHP Before<br>(Psia) | Lifting<br>Liquid Rate After<br>lifting (STB/day) | FBHP After Lifting<br>(Psia) | FWHP<br>(Psia) | Gas Injection Rate<br>(MMSCFD) | W.C % |
|-------|---|-----------------------|---|------------------------------|----------------|--------------------------------|-------|
| 2003  | 1625                                    | 1185                  | 1607  | 1208                         | 741            | 6.456                          | 1     |
| 2006  | 420                                     | 2117                  | 514   | 1989                         | 1000           | 1.476                          | 0.03  |
| 2009  | 246                                     | 1442                  | 302   | 1140                         | 710.5          | 0.367                          | 4.3   |
| 2012  | 1716                                    | 745                   | 1165  | 1130                         | 248            | 1.333                          | 0.65  |
| 2014  | 989                                     | 996                   | 1349  | 725                          | 248            | 1.778                          | 1.2   |

In addition, commencing an artificial lift system at early stages of the reservoir life is more efficient to provide flexible drawdown through the rest of the production life. This will eliminate the restriction made by tubing string capacity for specific gas volumes to be injected if continuous flow gas lift system is installed. So that production rate can be increased or maintained at an economic rate (Fig. 3, Tables I, II)

1. Individual well performance with gas lifts system under the actual flow line pressure.
2. Increasing drawdown by reducing FBHP to reduce reservoir pressure declining rate.

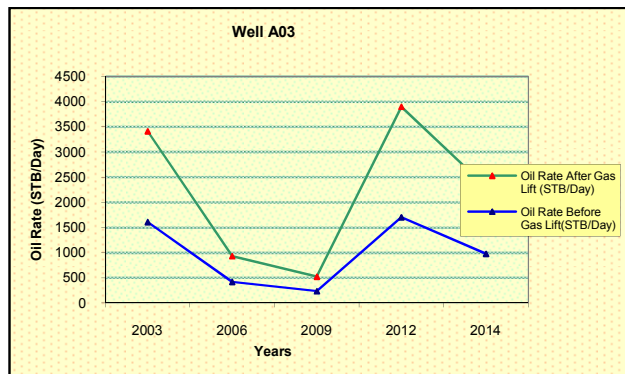


Fig. 3 Output design results of well A03

Introducing an artificial lift system at early stages of depletion may not be attractive from the economic point of view but, in case of Wafa field, it should be reviewed carefully because of the field location and history. This was examined by conducting design runs based on actual field data collected on January 2003 before the field was put into production.

One additional design run was performed for well A03 for year 2014 producer where the well head pressure was set at 248 psi to eliminate the back pressure effect. The design output results indicated that flow rate was increased by 36.4 % (Figs. 4-8 & Table III).

TABLE II  
EFFECT OF REDUCING OF FWHP FOR YEARS 2003 AND 2012

| Years | Liquid Rate Before lifting (STB/day) | FBH Before Lifting(Psia) | Liquid Rate After lifting (STB/day) | FBHP After Lifting (Psia) | FWHP (Psia) | Gas Injection Rate (MMSCFD) | W.C % |
|-------|--------------------------------------|--------------------------|-------------------------------------|---------------------------|-------------|-----------------------------|-------|
| 2003  | 1625                                 | 1185                     | 1821                                | 793                       | 430         | 7.312                       | 1     |
| 2012  | 1716                                 | 745                      | 2205                                | 334                       | 100         | 1.333                       | 0.65  |
| 2012  | 1716                                 | 745                      | 2038                                | 506                       | 150         | 1333                        | 0.65  |

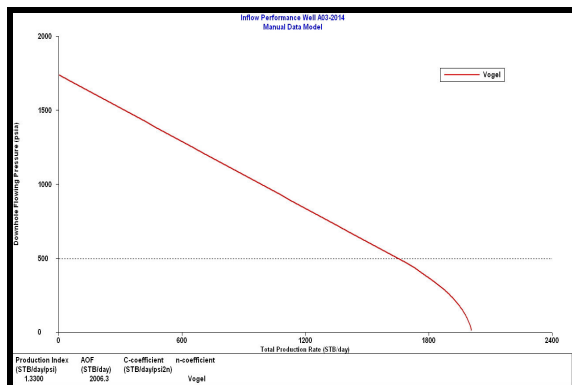


Fig. 4 Inflow Performance Curve of well A03 for year 2014

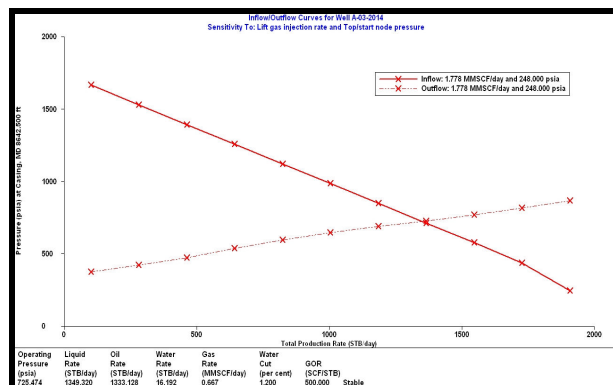


Fig. 6 Optimization lift gas injection rate of well A03 for year 2014

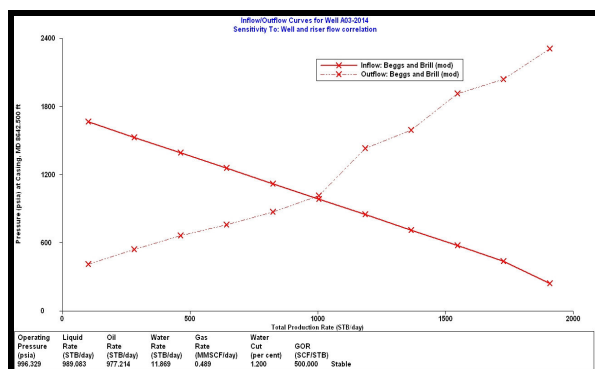


Fig. 5 Inflow/Outflow Curve of well A03 for year 2014

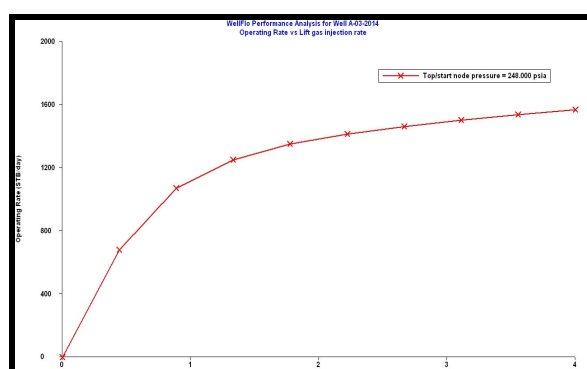


Fig. 7 Lift gas injection rate and Top/Start node pressure on Inflow/Outflow Curve of well A03 for year 2014

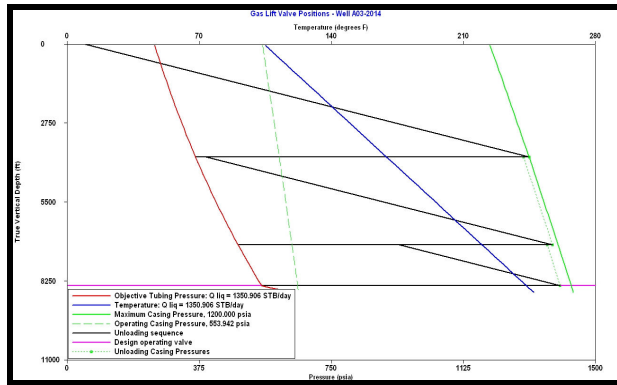


Fig. 8 Gas lift valve position of well A03 for year 2014

TABLE III  
SPACING CALCULATIONS OF WELL A03 FOR YEAR 2014

| Valve No. | Depth<br>TVD | Tv (degrees<br>F) | Port<br>Size | R      | DPc   | Pt    | Psc  | Pd&Pvc | OP     | Pso    | Pd@60F | TRO  | Set to Valve Descr. | Valve Model |
|-----------|--------------|-------------------|--------------|--------|-------|-------|------|--------|--------|--------|--------|------|---------------------|-------------|
| 1         | 3920.7       | 169.1             | 20           | 0.0996 | 106.3 | 363.6 | 1114 | 1216.3 | 1310.6 | 1200   | 976.3  | 1083 | GI Valve 1          | 1.5" IPO    |
| 2         | 6982.3       | 219.7             | 20           | 0.0996 | 184.1 | 484.5 | 1111 | 1288.3 | 1377.2 | 1186.4 | 949    | 1052 | GI Valve 2          | 1.5" IPO    |
| 3         | 8400         | 243.2             | 28           |        | 99.4  | 551.3 |      |        | 651.3  | 551.9  |        |      | GI Valve 3          | Orifice     |

## V. CONCLUSIONS AND RECOMMENDATIONS

1. Continues flow gas lift system approved to be efficient for increasing production rates for the vertical producers covered by this study based on the available data at time of investigation.
2. Timing for gas lift systems in Wafa field is highly dependent on the average reservoir pressure at time of implementation.
3. Gas availability would not be a limiting factor for using gas lift systems in Wafa field because of in situ gas volumes and makeup gas lines connecting it with other gas sources.
4. The performance of the gas lift systems would be peaked if formation damage is removed by Halliburton Stimulation (Acidizing, Additives or Hydraulic Fracture by using PermStim™ system is a newly designed fracturing fluid system and the gel is very clean, leaving little to no residue upon breaking (< 1%), leading to improvements of well cleanup.

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## ABBREVIATIONS

|       |                              |
|-------|------------------------------|
| AOF   | Absolute Open Flow           |
| API   | America Petroleum Institute  |
| Btm   | Bottom                       |
| D PC  | Differential pressure casing |
| EPSE  | Edinburgh Petroleum Services |
| FBHP  | Flowing Bottom Hole Pressure |
| FWHP  | Flowing well head pressure   |
| G.O.R | Gas Oil Ratio                |

|         |  |
|---------|--|
| G.L     | Gas Lift                                     |
| IPR     | Inflow Performance Relationship              |
| KOP     | Kick of Pressure                             |
| MMSCF/d | Million standard cubic feet per day          |
| MD      | Measured Depth                               |
| MPP     | Mid Perforation Point                        |
| OP      | Operating Pressure                           |
| Pt      | Tubing Pressure                              |
| Psc     | Surface Closing Pressure                     |
| Pd      | Dome Pressure                                |
| Pvc     | Valve Closing Pressure                       |
| Pso     | Surface Opening Pressure                     |
| Perf    | Perforation                                  |
| PI      | Productivity Index                           |
| Pwf     | Bottom hole Pressure                         |
| Pr      | Reservoir Pressure                           |
| PI      | Productivity Index                           |
| R       | Ratio between the bellows and port size area |
| Tbg     | Tubing                                       |
| TD      | Total Depth                                  |
| TRO     | Test Rack Opening                            |
| TVD     | True Vertical Depth                          |
| W.H     | Well Head                                    |
| WC      | Water Cut                                    |
| VLP     | Vertical Lift Performance                    |
| OWC     | Oil Water Contact                            |
| HSD     | Hole Inside Diameter                         |

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