A CONSTANT PRESSURE DESIGN APPROACH FOR IMPROVING GAS LIFT SYSTEM INJECTION DEPTH

Andres Molina, Sr. Petroleum Engineer,
Elevation Resources
Robert Strong, Petroleum Engineer,
Flowco Production Solutions
Kyle Patterson, Petroleum Engineer,
Flowco Production Solutions

ABSTRACT
The main constraint in a gas lift system is a limitation on injection volume and surface injection pressure due to the packaging and compressor capabilities available. In an ideal world, the system would have unlimited injection gas volume and unlimited injection pressure. This is often not the case with compressor availability and/or already existing facilities. These constraints can limit the design and efficiency of a gas lift system. This study was conducted to establish a method that would allow deeper injection without increasing compressor discharge pressure.

INTRODUCTION
With limited injection pressure on surface, a gas lift system is limited in the injection depth that can be achieved. The design must conserve as much surface injection pressure as possible, to maximize the lifting depth.

A drawback to typical internal pressure-operated (IPO) gas lift valves is that the valves take +/- 25 psi pressure drop/reduction between gas lift valves to transition properly. These pressure drops reduce the full potential of compressor discharge pressure that is available. This decreases injection depth and ultimately decreases production or ultimate drawdown. Although these pressure drops may limit injection depth, they allow for simple monitoring of the gas lift system by observing the surface injection pressure. The surveillance of these pressure drops can easily portray any problems the system might be experiencing.

With the constant-pressure design approach and the selection of an alternate style of IPO gas lift valve, an engineer can minimize or eliminate the need to take pressure drops and fully utilize the maximum available injection pressure. This is accomplished through valve mechanics where the pressure drop is taken over a choke at the point where injection gas enters the valve. This allows a larger tubing effect compared to a traditional IPO valve. In this paper we will refer to this style of IPO valve as a “Pressure Balanced” IPO gas lift valve. Since the injection pressure stays constant throughout the life of the well, an operator loses the ability to use the injection pressure to correlate the injection depth. This is a drawback for a pressure balanced IPO gas lift valve and can make it difficult to determine if the well is injecting at the intended depth.

The goal of this paper is to identify if using pressure balanced IPO gas lift valves as the upper “unloading” gas lift valves and conventional/traditional IPO gas lift valves for the lower “operating” valves would be a useful application to maximize injection depth. Each gas lift system includes a live downhole pressure gauge used to validate nodal analysis. The results from this study show that deeper injection and higher drawdown were achieved with these systems when compared to a standard IPO gas lift design. This study was conducted with Elevation Resources in the Permian Basin.

PRESSURE BALANCED IPO GAS LIFT VALVE FUNCTION

A traditional IPO valve in a conventional gas lift design in the closed position has the ball being acted upon by tubing pressure and the bellows acted upon by casing pressure. For a traditional IPO valve in the open position the bellows is only being acted upon by the casing pressure. Therefore, on a traditional IPO valve, you must drop the casing pressure in order to close the valve.

In a pressure-balanced IPO gas lift valve, the casing pressure enters through a choke as seen in **Figure 1**. In this diagram Pd is the valve dome pressure, Pc is the casing pressure, and Pt is the tubing pressure.

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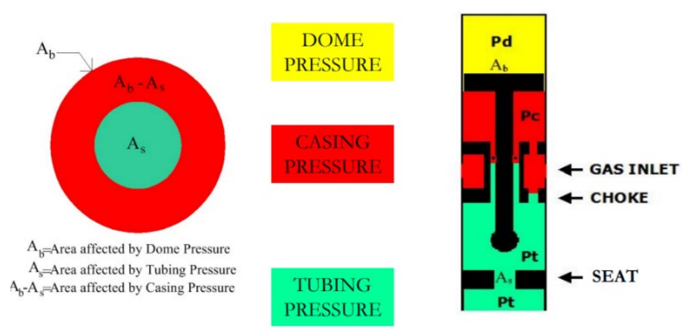

Figure 1 – Balanced Pressure IPO Valve Diagram

The choke provides enough of a pressure drop from the casing side to allow tubing pressure to continue to act on the valve in the open position. Due to this valve design it is not necessary to take pressure drops between valves like it is in a standard IPO gas lift valve design.

The application in this paper allows the design to conserve +/- 100 psi and inject deeper in the well. The deeper injection allows more fluid to be lightened and flowing bottom hole pressure (FBHP) to be reduced. The biggest drawback to the pressure-balanced IPO valves is that the operator loses surveillance ability on the casing side when trying to identify current lift point since there are no casing pressure drops. Also, since the pressure balanced IPO valves are affected by tubing/production pressures when in the open position this can lead to worse slugging in wells that already have slugging issues. Using a combination of pressure balanced IPO valves as the unloading valves and standard IPO valves as the operating valves allows the operator to conserve pressure and achieve deeper injection, while keeping the surveillance and operating characteristics of a standard IPO valve.

FIELD DATA AND APPLICATION

Now we will look at two field installations and how the application of pressure balanced IPO gas lift valves has impacted their performance. For both wells we evaluated production at 45 and 90 days from initial production.

After flowing for 45 days the UL 1H production data matches the blue lines in **Figure 2** and **Figure 3.** The 45 day casing pressure reads 1060psi which places our lift point, according to the surface closing pressure (PSC) of the conventional IPO valves, at 6330'TVD. This is one valve deeper than our model predicts, showing our flowing gradients to be slightly conservative at 45 days, but within reason. Comparing the gas lift designs and gradients in **Figure 2 and Figure 3**, our predicted lift point with a conventional IPO gas lift design is one valve higher at 5040'TVD versus 5685'TVD in the design using balanced pressure IPO valves as unloading valves.

The same analysis was performed for production 90 days from IP. At 90 days a casing pressure of 995psi was observed. Using PSC values this puts injection at 8265'TVD. This lines up with what our model predicts in this case. Comparing the gas lift designs & gradients in **Figure 2 and Figure 3**, our predicted lift point at 90 days with a conventional IPO gas lift design is one valve higher at 7620'TVD versus 8265'TVD in the design using balanced pressure IPO valves.

Nodal analysis was run using downhole gauge data to verify modelled flowing bottomhole pressures (FBHP) and an injection depth sensitivity was run to evaluate the theoretical uplift obtained in using balanced pressure IPO valves at both points in time (45 & 90 days of production). The results for the UL 1H Nodal Analysis are presented in **Figure 4**. At 45 days the analysis shows a theoretical uplift of 50 BFPD and a reduction in FBHP of 55 psi. At 90 days the analysis shows a theoretical uplift of 60 BFPD and a reduction in FBHP of 110 psi.

The analysis of the UL 2H provides very similar insight to that of the UL 1H. **Figure 5** and **Figure 6** present the designs and flowing gradients for the UL 2H. Production at 45 days and 90 days is shown by blue and red gradients respectively. The UL 2H casing pressure at 45 days reads 1055psi which places our lift point, according to the surface closing pressure (PSC) of the conventional IPO valves, at 6345'TVD. This is (just like the UL 1H) one valve deeper than our model predicts, showing our flowing gradients to be slightly conservative at 45 days, but within reason. Comparing the gas lift designs & gradients in **Figure 5 and Figure 6**, our predicted lift point with a conventional IPO gas lift design is one valve higher at 5045'TVD versus 5695'TVD in the design using balanced pressure IPO valves as unloading valves.

At 90 days, the casing pressure was slightly erratic but an average pressure of 980-990psi was observed. Using PSC values this puts injection at 8295'TVD. This is one valve deeper than what our model predicts in this case. Comparing the gas lift designs and gradients in **Figure 5 and Figure 6**, our predicted lift point at 90 days with a conventional IPO gas lift design is one valve higher at 6995'TVD versus 7645'TVD in the design using balanced pressure IPO valves as unloading valves.
The results for the UL 1H Nodal Analysis are presented in **Figure 7**. At 45 days the analysis shows a theoretical uplift of 30 BFPD and a reduction in FBHP of 60 psi. At 90 days the analysis shows a theoretical uplift of 10 BFPD and a reduction in FBHP of 30 psi.

CONCLUSION

Use of balanced pressure IPO gas lift valves as unloading valves may allow for deeper injection in gas lift wells. This has tangible benefits which may be magnified in wells with high productivity index (PI) and/or low gas to liquid ratios (GLR). Our application study, while limited, shows that balanced pressure IPO valves could be a useful tool in optimizing gas lift injection depth and improving production.

TABLES

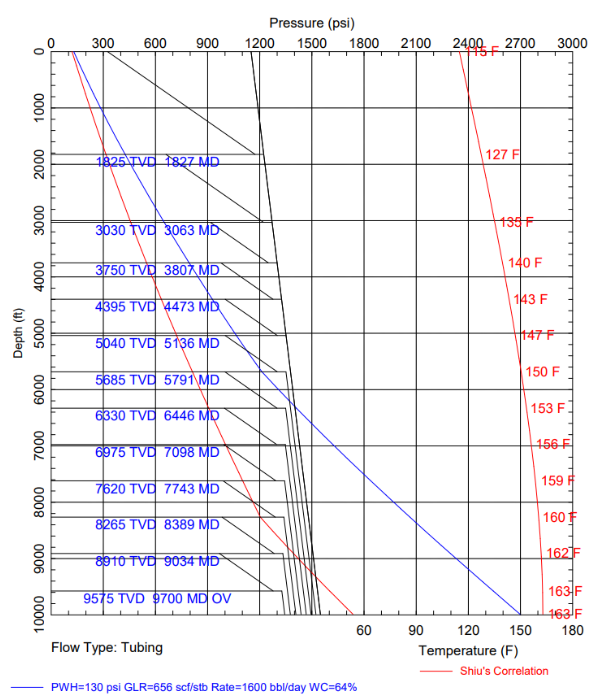

Figure 2 – UL 1H Pressure Balanced & Conventional IPO combination gas lift design showing the absence of pressure drops taken in the unloading mandrels.

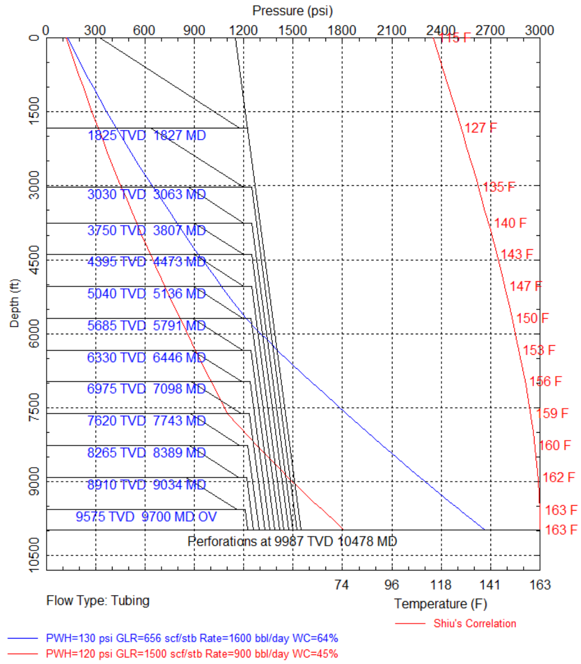

Figure 3 – UL 1H Conventional IPO gas lift design showing the higher predicted lift point when compared to the pressure balanced combination design.

Summary of Results - 45 Days						
Lift Method	Injection Depth (TVD')	Injection Volume (MCFD)	Total Fluid (BFPD)	WC %	BOPD	FBHP (PSI)
45 Days with Balance Ported IPO valves as unloading valves	5685	450	1650	64%	594	2850
45 Days with IPO valves as unloading valves	5040	450	1600	64%	576	2905

Diffrence in total fluid	50	BFPD
Diffrence in oil production	18.0	BOPD
Diffrence in FBHP	55	PSI

Summary of Results - 90 Days						
Lift Method	Injection Depth (TVD')	Injection Volume (MCFD)	Total Fluid (BFPD)	WC %	BOPD	FBHP (PSI)
90 Days with Balance Ported IPO valves as unloading valves	7620	790	870	45%	478.5	1980
90 Days with IPO valves as unloading valves	6975	790	810	45%	445.5	2090

Diffrence in total fluid	60	BFPD
Diffrence in oil production	33.0	BOPD
Diffrence in FBHP	110	PSI

Figure 4 – UL 1H Nodal Analysis results using downhole gauge data show theoretical uplift achieved with combination gas lift design's deeper injection point.

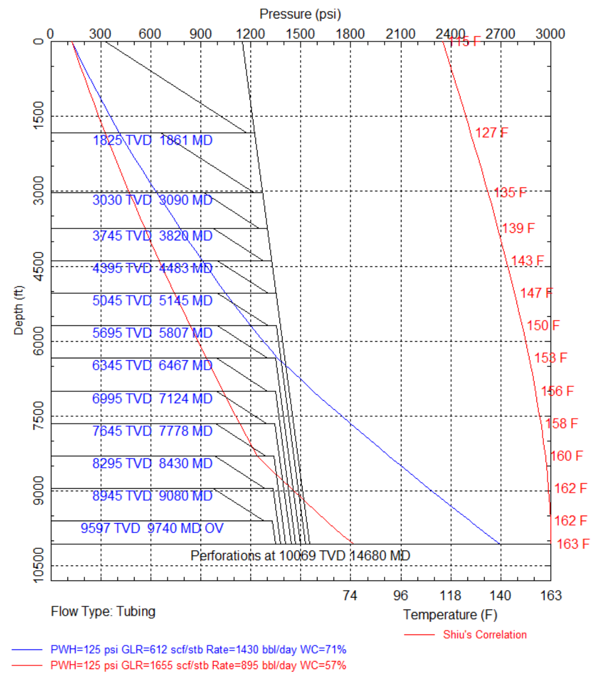

Figure 5 – UL 2H Pressure Balanced & Conventional IPO combination gas lift design showing the absence of pressure drops taken in the unloading mandrels.

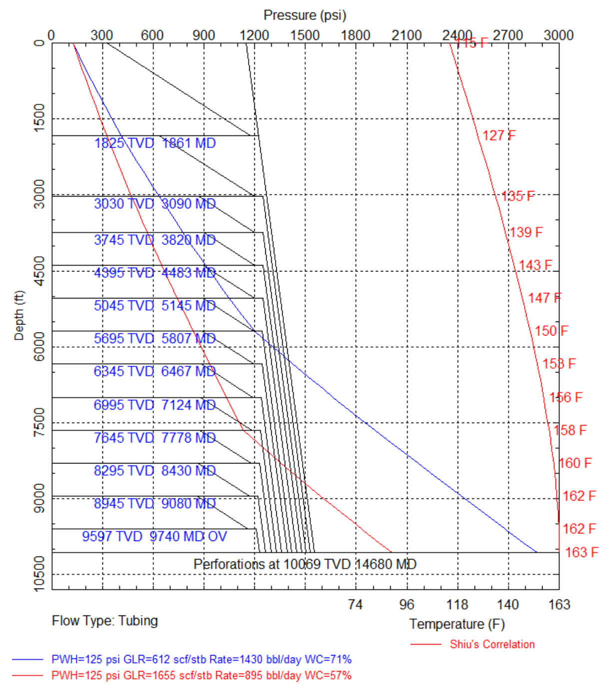

Figure 6 – UL 2H Conventional IPO gas lift design showing the higher predicted lift point when compared to the pressure balanced combination design.

Summary of Results - 45 Days						
Lift Method	Injection Depth (TVD')	Injection Volume (MCFD)	Total Fluid (BFPD)	WC %	BOPD	FBHP (PSI)
45 Days with Balance Ported IPO valves as unloading valves	5695	400 MCFD	1510 BFPD	71%	444 BOPD	2900
45 Days with IPO valves as unloading valves	5045	400 MCFD	1480 BFPD	71%	436 BOPD	2960

Diffrence in total fluid	30	BFPD
Diffrence in oil production	8.8	BOPD
Diffrence in FBHP	60	PSI

Summary of Results - 90 Days						
Lift Method	Injection Depth (TVD')	Injection Volume (MCFD)	Total Fluid (BFPD)	WC %	BOPD	FBHP (PSI)
90 Days with Balance Ported IPO valves as unloading valves	7645	850 MCFD	855 BFPD	57%	371 BOPD	1780
90 Days with IPO valves as unloading valves	6995	850 MCFD	845 BFPD	57%	366 BOPD	1810

Diffrence in total fluid	10	BFPD
Diffrence in oil production	4.3	BOPD
Diffrence in FBHP	30	PSI

Fig. 7 – UL 2H Nodal Analysis results using downhole gauge data show theoretical uplift achieved with combination gas lift design's deeper injection point.

ACKNOWLEGEMENTS

We would like to thank Elevation Resources for working with us to collect the data for this study.