ACHIEVING SUPERIOR DRAWDOWN AND GAS EFFICIENCY IN GAS LIFT OPERATIONS

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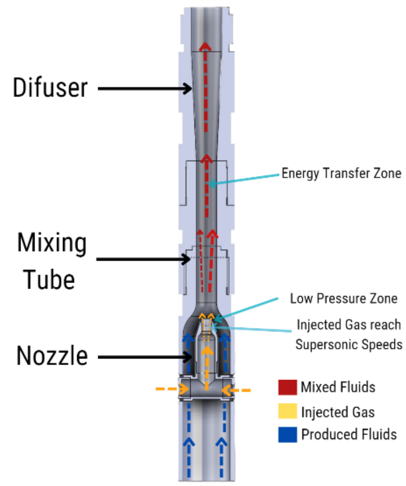
Introduction:

The DJ Basin has been using Gas Lift as one of the main artificial lift systems to produce the wells. While it has been a very cost-effective solution, the nature of the Gas Lift only allows the well to produce the maximum possible once the optimum injection rate is achieved and at the deepest possible injection point. Bison Oil & Gas IV (BOG), LLC is a Denver based upstream oil and gas exploration that operates over 220,000 net acres, managing approximately 500 wells with a daily production rate of 50,000 barrels of oil (BOE), positioning it among the largest private companies in the DJ Basin. Out of the 500 wells, 85% of them are currently producing with Gas Lift and most of the Gas Lif wells are injected into about 350-700 MSCFD with production ranges between 100-1,000 barrels of fluid per day. While looking at maximizing production on those Gas Lifted wells, BOG was interested in running the SST technology to evaluate the production gains and eventually expand the implementation across multiples wells in the field.

SST Technology

SST is a technology developed to improve Gas Lift Performance, the pump operates on the principle of venturi effect, where the injected gas passes through a nozzle increasing the speed of the gas creating a low-pressure zone at the throat. Also, the produced fluid then mixes with the injected gas in a diffuser transferring that energy to the fluid-gas mixture. While similar approaches have been tried in the past, for this new solution, supersonic speeds are reached by using a converging-diverging nozzle to reduce the pressure at the tip of the nozzle to maximize the overall suction and improve flowing bottomhole pressure.

Figure N. 1 - SST – How it works.



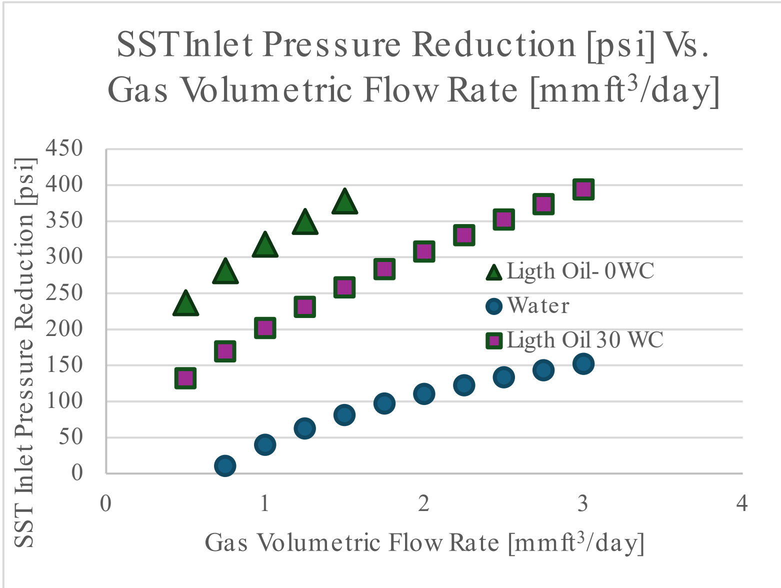
The suction generated by the tool is a function of function of several factors, but mainly

- Pump Geometry
- Injected Gas Rate and Pressure
- Flowing Bottomhole Pressure
- Produced Fluid Properties

Extensive Lab and Field Testing to support the mathematical model have been accomplished to better estimate the suction at different pump geometries

The Suction example on Figure N.2 shows how suction varies at different injection rates and fluid properties.

Figure N. 2 - SST Suction Example – Lab



Well Characteristics

For initial installations and trials, 4 wells were selected (Tatanka 615, Tatanka 625, Tatanka 670 and Tatanka 645). Most of those wells have very similar operational conditions with Gas lift completions with 2.375” tbg within 5.5 inches Casing, 7 GL stations with conventional mandrels (CM-1) with screen orifice at the bottom mainly size 12, retrievable packer at ~5600-6000 ft landing depth (Figure N.3). At the time of the installations, the IP was estimated to be ~0.25 to 0.35 with Static Pressure around 1500-2000 psi with Fluid properties of produce fluids with 38° API, ~30% Water Cut and 1,800 GOR (SFD/B).

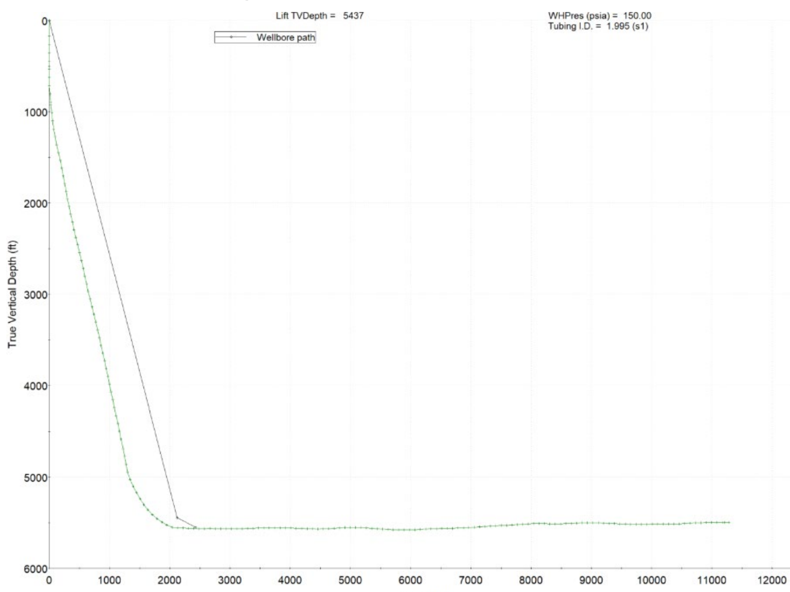
Figure N. 3 - Gas Lift Installation Sheet.

Tubing:		Casing:		Liner:		Packer:	
Size:	2.375	Size:	5.5"	O.D:	5.5"	Type:	5.5" AS1X 10k 20-23# Packer
Grade:	L80	Weight:	20#	I.D:	4.778"	Depth	5652.69
No. Joints:	172	Grade:	P-110	Top:	Surface	Wt. on PKR:	12k
Tail String		Perfs:	5574' TVD				
Design Info.		Gas Pressure:		Fluid:		Valves	
Fluid Prod.	1500 bbl/day	K.O.	1100	% H2O:	50%	Size / Port:	1.0" with 12/64" ports
Static B.H.P.		Operating:	1100	Fluid Grad.	0.45	Operation:	IPO GLV
P.I.		Gravity:	0.85			Checks:	1.0"/DBL Check Valve
W.H.B.P.	200F					Mandrel	CM-1 L-80 EP-2 Coating

Joints:	Spacing:	Depth:	I.D:	O.D.	PTRO:	PSO:	PSC:	Misc Data:
KB	23.00	23.00						Elevation
Hanger	0.50	23.50	1.995	7.06				Tubing Hanger
1	32.34	55.84	1.995	2.375				2-3/8" EUE- Slick Joint
10' Pup	10.04	65.88	1.995	2.375				10' Pup Joint
4' Pup	4.10	69.98	1.995	2.375				4' Pup Joint
3' Pup	3.00	72.98	1.995	2.375				3' Pup Joint
54	1748.87	1821.85	1.995	2.375				2-3/8" EUE
GLV # 7	4.10	1825.95	1.995	3.783	1055	1150	1120	12/64 Port-Gas Lift Valve/DBL Check VLV
20	650.46	2476.41	1.995	2.375				2-3/8" EUE
GLV # 6	4.10	2480.51	1.995	3.783	1040	1100	1091	12/64 Port-Gas Lift Valve/DBL Check VLV
18	585.00	3065.51	1.995	2.375				2-3/8" EUE
GLV # 5	4.10	3069.61	1.995	3.783	1025	1087	1060	12/64 Port-Gas Lift Valve/DBL Check VLV
19	617.11	3686.72	1.995	2.375				2-3/8" EUE
GLV # 4	4.10	3690.82	1.995	3.783	1020	1069	1040	12/64 Port-Gas Lift Valve/DBL Check VLV
18	582.53	4273.35	1.995	2.375				2-3/8" EUE
GLV # 3	4.10	4277.45	1.995	3.783	1020	1049	1020	12/64 Port-Gas Lift Valve/DBL Check VLV
18	582.30	4859.75	1.995	2.375				2-3/8" EUE
GLV # 2	4.10	4863.85	1.995	3.783	1020	1029	1000	12/64 Port-Gas Lift Valve/DBL Check VLV
12	386.94	5250.79	1.995	2.375				2-3/8" EUE
X-Nipple	0.85	5251.64	1.875	3.063		30 Deg.		1.875"- X-Nipple
11	355.95	5607.59	1.995	2.375				2-3/8" EUE
GLV # 1	4.10	5611.69	1.995	3.783	S/O	S/O	S/O	12/64 Port-Screen Orifice/DBL Check VLV
1	32.43	5644.12	1.995	2.375				2-3/8" EUE
On/Off	1.36	5645.48	1.995	4.5				On/Off Tool
PKR	7.21	5652.69	1.995	4.5		60 Deg.		5.5" AS1X 10K 20-23# Packer
4' Pup	4.06	5656.75	1.995	2.375				4' Pup Joint
XN	0.92	5657.67	1.791	3.063		Profile		1.791"- XN Nipple
4' Pup	4.04	5661.71	1.995	2.375				4' Pup Joint
P.O.P	0.40	5662.11	1.52	2.62				Pump Out Plug (SPINS 410#'s PER PIN)

The wells present a significantly high deviation with bottom mandrel located at ~65° angle and ~6-8 DLS as shown in Figure N. 4.

Figure N.4 - Well Deviation Plot.



SST Designs

To design and evaluate the SST, the initial step is to model as accurately as possible the Gas Lift performance of each well to determine the relevant information required to design the Supersonic Tool and estimate the suction and its corresponding uplift improvements in terms of production. For this purpose, two software were used, Pipesim (registered by SLB) and SNAP (National consulting). Below Figures 5 and 6 show the IPR Curves and Gas Lift Performance obtained for one of the wells for references, but as indicated, the wells share very similar characteristics with flowing pressure between 700-800 psi while Optimum injection gas rate between 350-700 MSCFD.

Figure N. 5 - IPR Curve

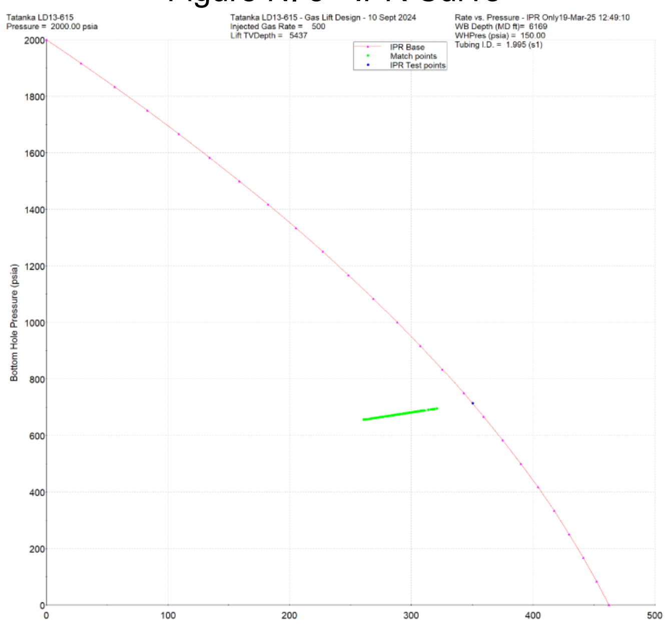
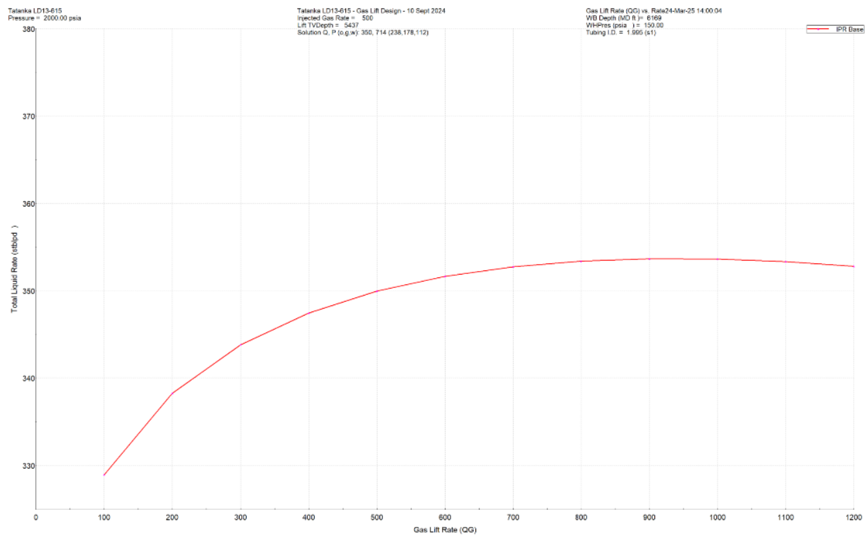
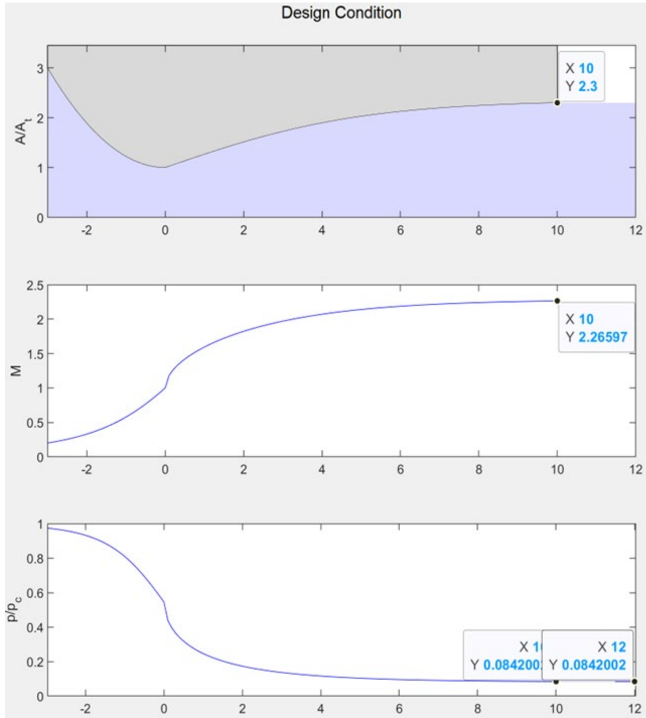


Figure N. 6 - Gas Lift Performance



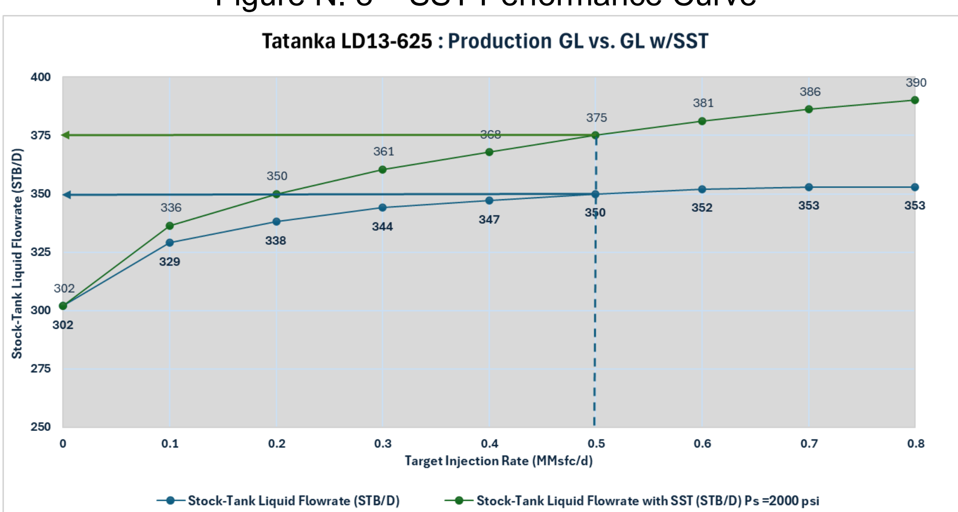
SST design and selection is done by proprietary TRC software using calculated production and operational parameters, the suction created by the tool is estimated to be ~ 90 psi considering a pump geometry of a Nozzle size with 7.5 mm and Diffuser size of 16.5 mm. The Nozzle profile (Converging-Diverging) is indicated on Figure N.7 showing that the selected profile will lower the injection pressure by 94% at the tip of the Nozzle while avoiding choke wave when achieving Mach 2.26. After including the flow losses across the accessories, the overall suction is estimated to be about 80-85 psi.

Figure N. 7 - Nozzle Profile (Converging-Diverging Nozzle)



After suction is estimated and the pump curve is built then uplift at different injection rates was calculated to determine the SST Performance curve and compare to Gas Lift Stand-Alone to estimate the production gains and/or gas savings. Figure N. 8 shows the Performance curves for one of the wells.

Figure N. 8 – SST Performance Curve



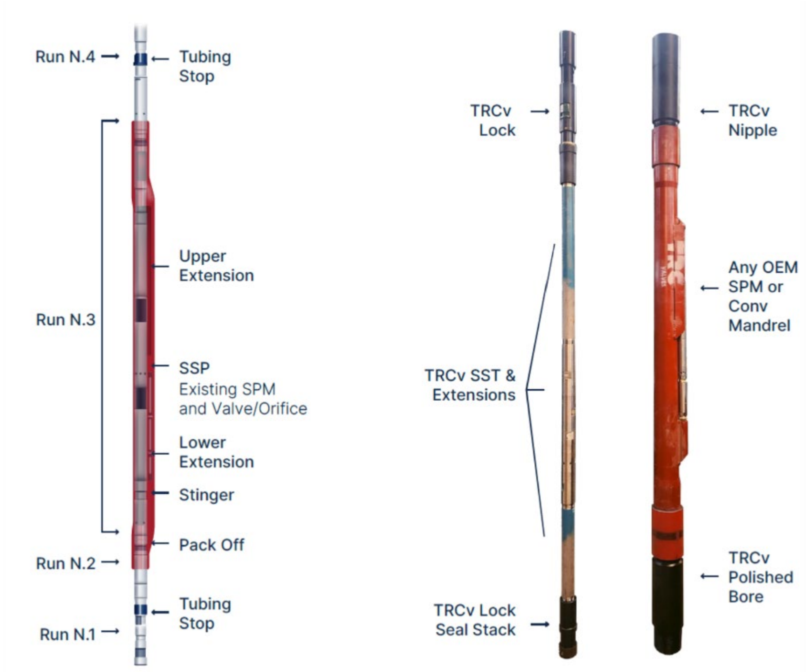
About 8% production gains were calculated and installations started in Q3 of 2024 to evaluate production gains and confirm/validate model and benefits.

SST Installations

4 runs slickline installations were initially used to isolate the Point of Injection (Bottom Gas Lift Mandrel) – Figure N. 9 shows stack up required to isolate the Gas Lift Mandrel using Tubing Stops and Pack-off on both ends. As shown on Deviation Plot and DLS at the point of injection poses a risk for slickline operation to properly set the tool such as Tool Stacking & Jarring Failures - Gauge rings and SST Valve repeatedly stacked out, requiring multiple jarring attempts to pass restrictions, Shearing & Slip Stop Failures - Slip stop tools failed to shear at intended depths, Pack-Off Set & Retrieval Issues - Multiple attempts were needed to successfully set and retrieve pack-off tools necessitating additional runs.

3 of the wells were successfully installed using this configuration, however in one of the wells workover was decided to complete the installations properly as challenges to run the accessories to isolate the point of injection make it unable. The Tubing deploy option is a much easier way to install the tool where high deviation is encountered.

Figure N. 9 - SST Installation (4 run slickline on the left and Tubing Deploy or single run Slickline on the right)



SST Evaluation

After completing the initial installations, wells were tested and DCA Analysis is used to determine the production gains. Figure 10 shows production gains after installation showing the expected and as per design

Figure 10. Production Gains after installation

Other wells show production gains as per DCA analysis below.

Figure N. 11 - DCA Tatanka 615

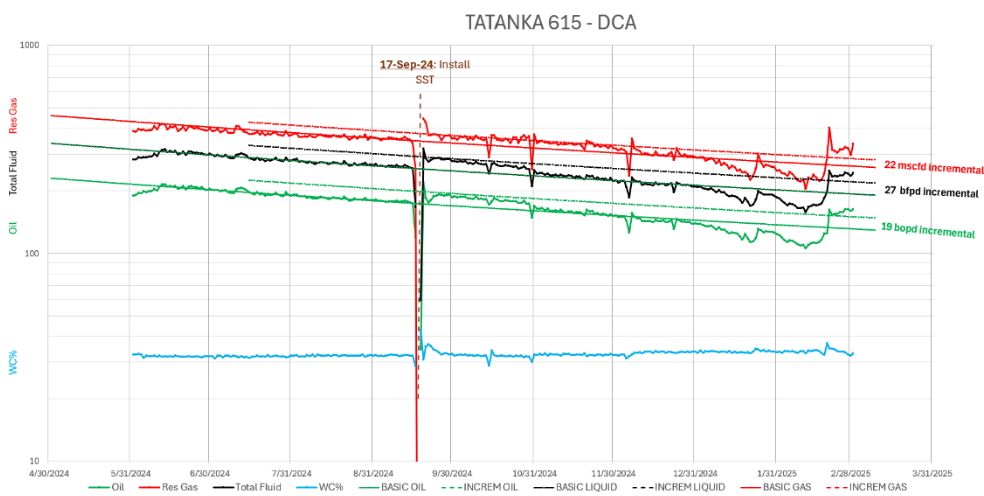


Figure N. 12 – DCA Tatanka 645

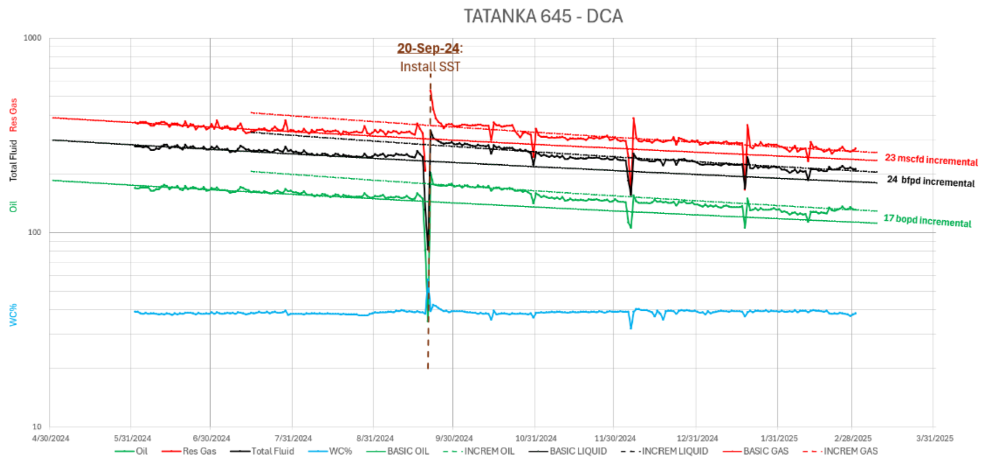


Figure N. 13 – DCA Tatanka 650

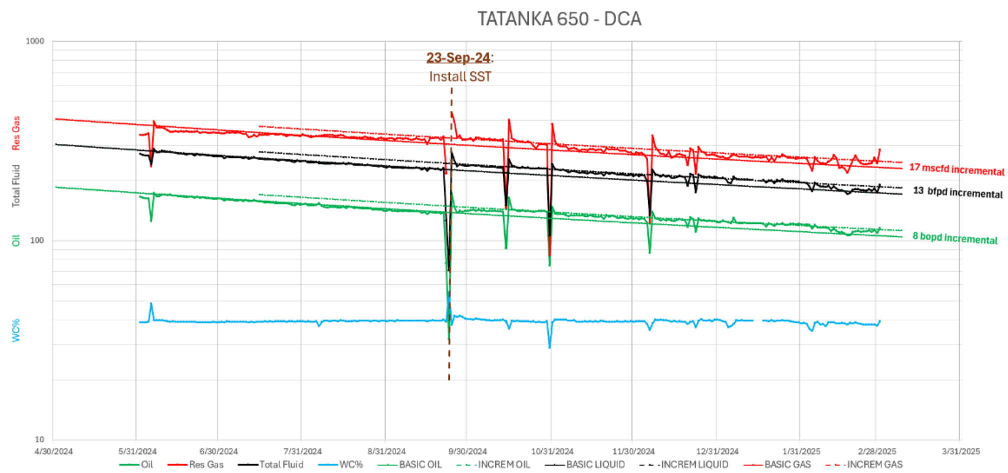
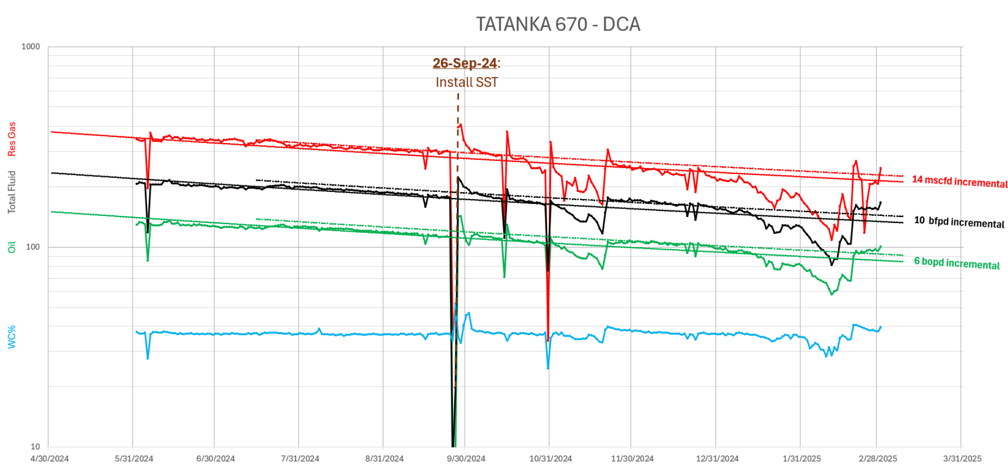


Figure N. 14 – DCA Tatanka 670



Production gains were in the range of 5-8% for those wells, as shown in the figures above, From December to Mid-February, Tatanka wells were operating without one of the compressors on this pad hence the lower production due to lower injection rate but were able to maintain most of it due to the installation of SSTs and less required injection gas.

As of March 2025, the SST installation has been expanded to 10 additional wells.

Conclusions and Opportunities for Improvements.

While production gains were achieved across almost all installed wells and gains were within 80% of designs, the SST is considered now a viable way to increase production on Gas Lifted Wells for DJ Basin. In addition, there are still opportunities for improvement to further improve production gains and operational efficiencies.

- Pump Geometry
- Combination with Plunger
- Single run has shown better performance
- Ability to maintain production with less production gas
    - Remove compression, Lower monthly LOE
- Tools successfully deployed in 2-3/8” & 2-7/8” tubing applications
- Deploy tools earlier in well life to see rate limitations and long-term effects (shallowing decline)