First In-Situ Gas Lift system in Offshore Saudi Aramco

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Abstract

In August 2004, the first In-Situ Gas Lift system, utilizing reservoir gas cap energy, was successfully installed in a mature Y offshore well that was unable to flow to the surface. The selection of this particular artificial system was made because it was the most economic alternative in Y field to overcome the challenging of the reservoir complexity and fluid encroachment problems, which has been identified by openhole logs. The previously shut-in well is now able to produce up to 4, 000 barrels per a day. Based on productivity improvement and successful operation vast potential application of this technology will be considered in Saudi Aramco fields with natural gas cap to maximize reservoir sweep efficiency.

This paper discuss in detail the first In-Situ Gas Lift system equipment, gas lift operation principles utilizing the gas cap, installation procedure, production strategy and well performance utilizing online monitoring system.

Introduction

The Y-279 well was revived using innovative completion methodologies to achieve incremental reserve recovery after the well had stopped producing due to water production. The Y-279 well was previously drilled into the K reservoir where the production zone is divided into two separate intervals that are supported by a strong aquifer. In this field called Y, as the water cut reaches at 20%, the wells die. To further add to the production challenges, when the water cut increases, the formation produces sand.

A common solution to overcome this hydrostatic pressure is to utilize some form of artificial lift via submersible pump or gas lift. To increase the reserve recovery for Y-279 well, the method of artificial lift chosen to restore production had to be compatible with the installation of a sand retention completion required to produce oil and water without producing formation sand. Production was restored in Y 279 well by utilizing a Baker Oil Tolls innovative completion system called Natural Gas Lift.

With this technology, a huge gas cap available in the K reservoir was utilized, allowing continues oil production as reserves are depleted and the oil water contact moves up into each interval. To address future isolation of water production, the completion design is segmented into two separate intervals allowing commingling of production and isolation as necessary to prevent water production. A completion is also installed in the gas cap for delivery of the gas into the production stream and to provide rate control of the gas lift gas as illustrated in Figure 1.

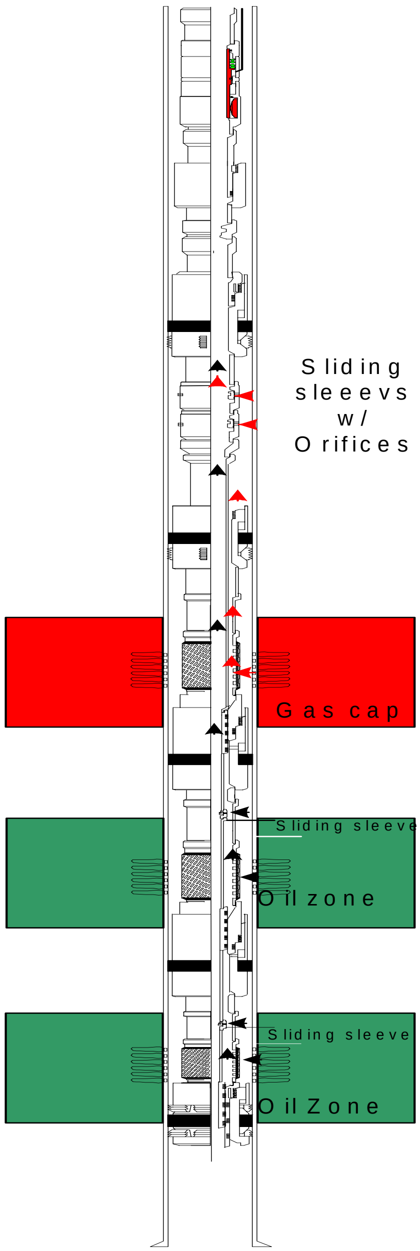

Figure 1
Natural Gas Lift Completion Design

Completion Selection

There was no existing sand control completion system available in this field. If incremental oil is going to be recovered, the oil is going to be produced along with water. To prevent sand production which occurs with the introduction of water into the production stream, a sand retention device such as a sand screen is needed. For Y-279 well, the sand screen selected is the Excluder2000 for both the oil and the gas zones. This type of screen is designed to have great durability and resistance to erosion and plugging.

In order to achieve isolation of encroaching water for the two producing intervals in the K reservoir, it was selectivity chosen between the oil zones by integrating a concentric string with sliding sleeves into the sand control completions. These sliding sleeves are shifted mechanically to commingle or isolate production.

Introduction of gas lift into the production stream without having separate gas lift facilities is achieved by integrating a completion in the gas cap with the sand control completions in each of the two oil producing zones. For the upper completion and the gas lift, the idea to provide a simple and reliable solution that is easy to operate. Effective gas lift is achieved with sliding sleeves containing orifice inserts that control the rate of gas injected into the hydrocarbon production stream.

Saving Rig Time

Since rig times in the offshore are expensive comparing to onshore operations, a two trip installation was chosen in order to minimize time required and reduce cost. The completion sequence was made in order to group all the common operations and optimize the completion installation time. Perforating time was minimized by running perforating guns for all intervals in single trip. The installation of sand control screens and packer assemblies for all the oil and gas zones was performed in a single trip. The well was completed with a final trip to run the production assembly in a single trip inclusive of the concentric completion string with the selective zonal isolation sleeves, the gas lift accessories, the upper production packer, and the tubing retrievable safety valve. The installation procedures were a success and the well was completed 5 days ahead of shecduled.

In-Situ gas lift system

The In-Situ Gas Lift System utilizes the K gas cap as the energy source for lifting the oil production as water encroaches into the production zone. For Y-279 well, the gas cap sandface completion consists of a stand alone screen with a Baker SC-1 GP Packer placed opposite the gas zone. A 4 ½ in OD screen is placed in front of a perforated interval (+/- 18 ft) and gas is injected into the tubing using a CMU Non-elastomeric Sliding Sleeve with tungsten carbide orifices.

The Natural Gas Lift sleeves can be opened with slick line as the water breaks through and the production target can no longer be met. The orifice sizes selected (¼" and 3/8") is based on the pressure differential at the orifice. The differential pressure at the orifice has been calculated building a 2 well system, one from bottom hole to injection point and the second one from the injection point to surface. The scope is to get the pressure at the injection point that will determine the amount of gas injected with a given orifice and calculate the new wellhead pressure (WHP) based on the amount of gas injected as shown in Table 1 and Figures 2 and 3. The amount of gas injected will change with the increase in pressure differential resulting from changes in Water Cut at a given rate. The result is an increase in the GLR, thereby providing enhanced lifting capabilities.

WC, %	0	10	30	50	70
WHP	815	764	678	586	500
GLR	403	363	282	202	121
GLR from Nat. Gas lift	546	506	431	355	280
Gas rate, Mscf/d	1.71	1.74	1.79	1.84	1.88
ΔP available, psi	215	164	78		

Table 1: Req. Gas Rate W/increasing water cut

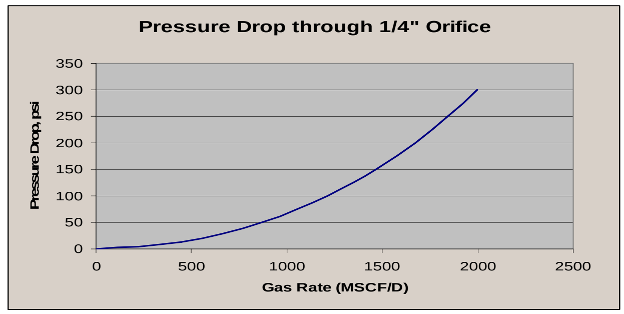

Fig. 2: Pressure Drop for ¼" Gas Lift Orifice

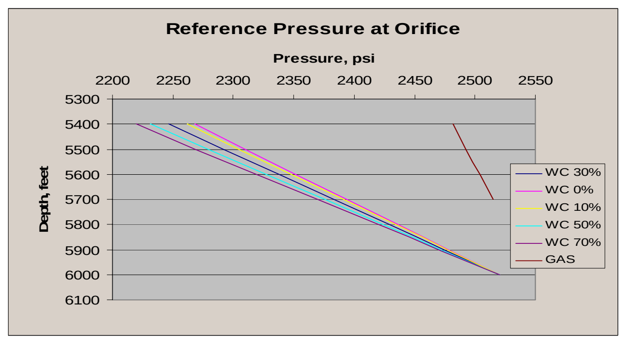

Fig. 3: Reference Pressure vs. Water Cut

At water cut levels below 40%, the well is able to produce more than 12,000 bbl/d. Slightly larger orifices (9/32 to 11/32") enable the well to produce at higher rates and higher water cuts.

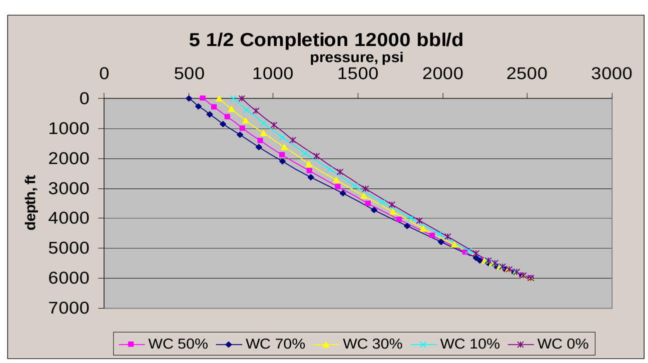

Figure 4: Production Inflow Rates vs. Water Cut

Like the conventional gas lift, the tubing size is affects the amount of gas required mainly due to changes in friction. The tables below show the effect of the tubing size on the total GLR required for a given rate:

Rate 12000bbl/d, 30% WC

Tbg size	3 ½	4 ½	5 ½	7
GLR required	>1000	570	431	400

Rate 8000bbl/d, 30% WC

Tbg size	3 ½	4 ½	5 ½	7
GLR required	>900	480	431	420

Impact in the Completion Skin

With the Natural Gas Lift option integrated into the sandface completion, it is possible to overcome formation damage / completion skin using the energy provided by the lifting system. In the plots shown below, 3 simulations with a completion skin of 0, 10, 20, and 30 have been made in order to demonstrate how the natural gas lift potential can improve the completion efficiency. The plot is showing, at a given production rate of 12000 bbl/d, the amount of gas delivered by the system with a ¼" orifice for a skin value up to 30 and a water cut <30% and for a 3/8" orifice choke the skin value and a WC >30%.

The amount of gas delivered is a function of Water cut and Skin, and the amount of gas needed for lifting purpose at a given rate of 12000 bbl/d could be up to 4.8 MMscf/d.

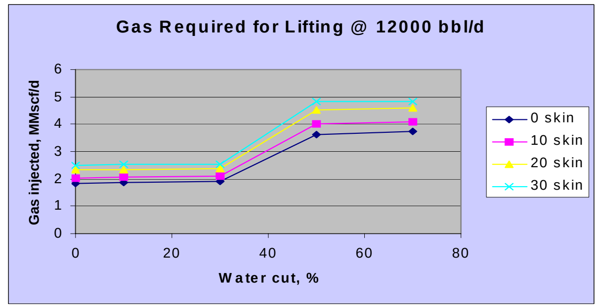

Figure 5: Completion Skin Impact on Required Gas Rate vs. Water Cut

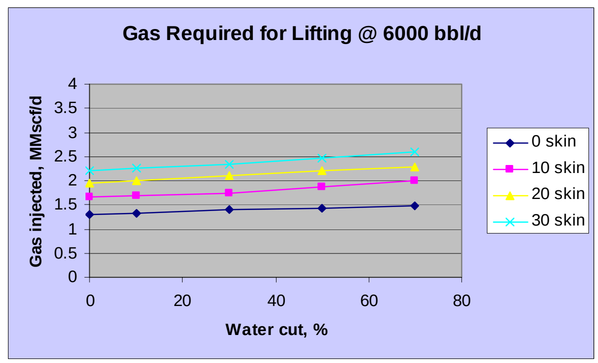

Figure 6: Completion Skin Impact on Required Gas Rate vs. Water Cut

Conclusions

- The application of In-Situ gas lift can save rig time and revived dead wells.
- The completion skin must be taking into consideration when applying this technology.
- San control system must be installed in sand produced wells in order to avoid any damage of the completion system.
- The orifice sizes must be designed carefully in order to get the pressure at the injection point which will determine the amount of gas injected with a given orifice for calculating new wellhead pressure