BALL LIFTING SYSTEM FOR DEEP LIFT AND OTHER APPLICATIONS

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Plungers and More

ABSTRACT

Each month there are a considerable number of horizontal, multi-pad wells drilled into the shale plays around the world coming online. Due to these wells having a substantially high bottom-hole pressure, these wells are initially capable of flowing on their own, without assistance or in conjunction with gas lift assemblies. However, as bottom-hole pressures decline and the flow begins to subside, other methods of artificial lift should be looked at. The decline in pressures and lower production rates creates a very challenging environment for operations to produce multi-pad horizontal wells.

This paper discusses the principles of the ball lifting system for deep lifting and its possible applications in conjunction with the two-piece plunger application (a ball and hollow cylinder). The ball lifting system will continually operate in the transition area, to deliver the ball to the lifting sleeve, while unloading wells and working itself to the bumper spring. This will provide an increased lifting depth from 40 to 80 degrees, effectively stopping the yo-yo effect, also known as ball separation, that is commonly seen between two-piece plunger systems. This assembly is used to remove fluids and hydrocarbons from subterranean wellbores. It will act as an orifice to capture hydrocarbons from dead space around the bumper spring and centrally force those hydrocarbons to the plunger assembly with maximum velocity, allowing operations to have higher quality plunger processes further down the curvature of deviated and horizontal wellbores. This paper will discuss the equipment used for the test and note the points of caution and concern when using the ball lifting system.

INTRODUCTION

The goal of this paper is to convey what has been learned in case studies from the ball lifting system that was used in conjunction with the two-piece plunger assembly. It is not meant to persuade operators to convert wells to the ball lifting system, but simply to share information to help individuals decide if the ball lifting system used cohesively with the two-piece plunger or rod-shifting assemblies is a solution for deviated and horizontal wellbores rather than converting to the more costly rod and pump assemblies.

Data was collected over the course of several months on lower producing horizontal well pads which utilized the ball lifting system, ball and sleeve or rod-shift plungers, gas assisted plunger lift method (GAPL), and the data points for oil production, gas production, and gas liquid ration or GLR rates.

OPERATIONS

Nearly 40% of wells around the world are on some type of artificial lift. As the reservoir pressure begins to deplete, these wells will often accumulate liquid in the well-bore creating a hydrostatic condition that will inhibit the flow of liquid and gas out of the wellbore, establishing the need for a cost-effective artificial lift system. Plunger lift systems, especially the two-piece configuration, have the benefit of increasing production in a lucrative manner on wells that no longer retain the ability to flow on their own. The ball lifting system working cohesively with the ball and sleeve configuration can be challenging to operate but can be a very cost-effective way of producing wells if the right training and processes have been implemented.

Theoretically, gas assisted plunger lift in conjunction with the ball lifting assembly and two-piece plunger is seemingly easy to operate due to the straightforward operations of the system. A flow control valve is actuated by selected trigger points in the electronic flow meter (EFM), gas is consistently being injected, facilitating the surfacing of the ball and sleeve. The ball and sleeve arrive in the lubricator, triggering the EFM to begin looking at critical velocity, while the ball begins to fall against the inflow of gas and liquids. However simplistic the theoretical application of this system is, the operation of these plunger systems are not as simple to optimize as they may seem. After several failed attempts to operate the ball lifting system with the ball and sleeve application, adjustments were required.

To improve operations, operators first need to thoroughly understand the ball and sleeve plunger assembly along with its components. Operators must understand how to check seating of the ball within the sleeve, physical checks of the sleeve, rod and spring wear, anvil wear, in addition to surface valving and available compression. A ball lifting system standard operating procedure was created to ensure this component was properly inspected. By training operators and implementing the necessary tools, the ball lifting system has a much better chance for success, compared to the pilot program.

EXISTING PLUNGER LIFT CASE STUDIES

There are many existing plunger lift wells in the San Juan Basin possibly operating below their potential due to the depth of bumper spring placement. Operators could encounter different wellsite layouts, different compression, but possibly the biggest struggle operations encounter is addressing how to produce lower volume wells and their inability to lift liquids from deeper within the curvature of the wellbore. To combat this potential loss of revenue, sustained training and maintenance programs are recommended, which in turn can allow for deeper lifting plunger systems - to depths at 80 degrees in the curvature of horizontal wellbores.

The remainder of this paper will give short descriptions of several wells utilizing the deep ball lifting system, efforts that were required to get the ball lifting system to run successfully, production rates, and issues that were encountered. The identity of the companies and specific test locations will not be disclosed to the public.

APPLICATIONS FOR BALL LIFT SYSTEM

Typical applications are:

1. Acts as moving standing valve to minimize dry runs while reducing tubing wear.
2. Will continually operate in transition area; ball lifting assembly will move to the transition flow area to deliver ball to lifting sleeve, unloading wells and work itself to the bottom.
3. Increase lifting depth from 40 degrees to 80 degrees.
4. Stop yo-yo effect between two-piece plungers.
5. Ensure seating of rod-shift plungers for a continuous and fluid runs to plunger.

A ball lifting assembly for a plunger lift system is employed to remove fluids and hydrocarbons from deeper within subterranean wellbores. The ball lifting sleeve is meant to act as an assembly that will sit on a bumper spring while it fluidly engages (e.g., unites) and disengages with plunger assembly. The sleeve acts as an orifice to capture hydrocarbons from dead space around the bumper spring and centrally force hydrocarbons to plunger assembly with maximum velocity. The ball lifting sleeve provides transfer of ball and liquid column to lifting plunger and assists in transitioning flow area. Additionally, the ball lifting assembly ensures a good seat of the rod-shift assembly. The sleeve provides softer fall rates reducing damage to lifting plunger and bumper spring. The ball lift assembly provides higher quality plunger operation further down curvature of deviated and horizontal wellbores, providing deeper lifting capabilities. The sleeve provides standing valve principles to horizontal and vertical wellbores. The ball lifting assembly will unload high volume liquid loads by acting as a movable standing valve and gradually working its way to bumper spring. The ball lifting assembly can be utilized to replace bumper springs, reducing tubing restrictions downhole.

DEEP LIFT PLUNGER WELL RESULTS

Well #1 was an existing plunger lift system, using a ball and hollow sleeve, that was utilized to produce a horizontal well in the San Juan Basin. The bumper spring was lowered to 6057' at 80˚ within the curvature of the wellbore. The installation and initial commissioning of the deep lifting device was overseen by the developer in September 2019; the deep lifting device was dropped into the wellbore with a steel ball and 6” hollow sleeve following in kind. In the months prior to installation GLR averaged 30.1 per month with the GLR falling to 25 after the installation; plunger arrivals averaged 13 minutes over the course of the pilot program. During the prior seven months the oil total was 1211 or an average of 173 barrels of oil a month while gas averaged 5067 or 723 per month. During the next seven months, the oil average per month increased to 186, while gas dropped slightly to 4430 or 632 per month. Over the course of the last seven months the oil increased again to average 193 barrels a month, while the gas up-ticked slightly to 647 from the previous 7-months.

Well #2 was an existing plunger lift system utilizing a ball and sleeve system that was producing in the San Juan Basin. This well’s bumper spring was lowered to 5055 at 80˚ degrees within the curvature of the wellbore. The installation and initial commissioning of the deep lifting system was conducted by the developer in October 2019; a 1.88 7” sleeve with steel ball was dropped following the deep lifting device. The average for production six months prior to installation was 3143 barrels of oil (523 bbls per month) and -694 gas (-115 gas per month). Well #2 was an unusual case as it needed to buyback a disproportionate amount of gas to produce oil. Due to the excessive amount of buyback gas, the GLR was -15.33. After the ball lifting device was installed another 6-month average was taken. The well had produced slightly more oil at 3191 barrels of oil (531 bbls per month) but increased its gas production by a stark 2370 MCF (395 gas per month); a 3064 MCF gas difference from the previous 6-months. Over the course of the next 6-months, the well continued its climb of oil to 3240 barrels of oil (540 bbls per month) and less gas, 1636 MCF (272 gas per month), but still a vast difference without the deep lifting device. At the end of the pilot test, the GLR was 0.153, indicating the well had begun to use the reservoir pressure and ball lifting assembly to bring liquids to surface.

Well #3 was an existing horizontal well that was running a ball and sleeve plunger lift system. The bumper spring was lowered to 5806’ at 80˚ within the curvature of the wellbore. As with wells #1 and #2 the developer conducted the installation and initial commission of the ball lifting device on March 24th, 2020. The ball and sleeve were dropped in conjunction with the deep lifting device. During the prior 7-months the well averaged 163.33 barrels of oil and 4817.48 gas per month with an average GLR of 26.25. After installation of the ball lifting device, over the course of the next 7-months, the well began to average 217.99 barrels of oil and 7638.70 of gas, with a GLR of 28.53.

<u>BALL LIFTING SYSTEM FOR OTHER APPLICATIONS</u>

Well #4 is an existing horizontal well in the San Juan Basin utilizing a rod-shift plunger system with the bumper spring installed at 48˚ within the curvature of the wellbore. The installation and initial commissioning of the ball lifting system was completed by an experienced lease operator with intimate knowledge of how rod-shift and ball and sleeve plungers operate on April 1st, 2021. The operator removed the ball and sleeve system, dropped a ball lifting assembly with a rod-shift plunger, and removed all injection gas from the well. The plunger system began to immediately operate, reaching its oil target within a day and utilizing only the natural reservoir pressure, eliminating the need for injection from compression. Within a three-day timeframe, the ball lifting assembly and rod shift plunger exceeded target by four barrels. The ball lifting system provided enough energy for the internal rod to seat within the plunger and make consistent runs. The pilot for this well is ongoing.

<u>SUMMARY</u>

When confronting how to address the natural decline of wells and what method is appropriate, many operators do not consider lowering bumper springs.

Operation of plunger lift systems, especially in horizontal wells, encounter two main issues that cause the typical patterns of production increasing and decreasing:

1. Field personnel understanding and training of processes from EOT to surface that should include plunger selection and downstream factors such as chokes, automation, dumps, surface piping, and separation.

2. The secondary, but primary issue, is the plunger is slowed or stopped from reaching the bumper spring due to gravity/friction issues and flow patterns within the tubing.

Most of these wells are not truly vertical, even to target depth, various radius curves or back build and reach for proper lateral spacing is encountered, in some cases as shallow as 1,000', which causes additional friction and constant changes in velocities and flow patterns. This is especially prevalent on multi-pads; flow changes occur from EOT, throughout the tubing string, to surface. Due to the bumper spring's configuration, there is a self-induced flow pattern that is caused as fluids and gas flow pass through it, diverting it from annular flow to tubing perimeters. The design of the ball lifting assembly was created to better utilize the available energy caused by these unchangeable flow parameters that are encountered. The ball lifting system has a larger surface area on the bottom, which efficiently utilizes the energy created by gas and liquids as they flow around the bumper spring. In deep lift applications, the stratified flow patterns utilize hydrostatic head to effectively seat the ball (in cases of the ball and sleeve plungers) on top of the ball lift assembly and distributes the available energy across the bottom of the lift assembly to start upward movement; the assembly will also act as a travelling check valve, trapping the lifting plunger liquid residue, and driving it to the bottom, as seen in the Echometer plunger slides below. Deep lift applications, there is much less energy required to start movement; this is comparable to midstream pigging applications - less energy is required to start a pig's movement horizontally versus launching up a hill. Regardless of where a bumper spring is seated, there will be a low-pressure cone, or transition area, developed above the fish neck. This is where most plungers lose their lifting and descending capabilities by stalling, stopping before reaching the bumper spring to shift the rod or catch the ball, or experiencing a constant yo-yo effect, as commonly seen with the ball and sleeve plunger assemblies. Once the ball lifting assembly moves through this low-pressure zone, the flow pattern changes back to annular, thus, eliminating ball lift energy so it can return to bottom while the lifting plunger can complete the lift cycle. The short length of the ball lifting assembly reduces friction in the deviation and curvature of the wellbores, allowing it to effectively operate in the transition flow areas and return to the bumper spring, overcoming friction created by horizontal movement, successfully delivering the ball to lifting sleeve or shift the rod in the rod-shift plunger assemblies. Optimizing the well energy available to where and when it is needed, operations can lower operable FBHP at the targeted formation, where other types of artificial lift are unable to operate and obtain the most recovery from formation economically.

Utilizing the ball lift assembly can lower the lifting depth of the plunger system, with little down time, and utilizing equipment already existing on-site, therefore, making the device a cost-effective alternative to the previously mentioned options.

Plunger Lift Well Data

Plunger Lift with Ball Lift Assembly	START OIL BBLS/M	END OIL BBLS/M	START WATER BBLS/M	END WATER BBLS/M	START GAS MCF/M	END GAS MCF/M	START GLR	END GLR
WELL #1 7 MONTH AVG.	173	193.42	302.28	336.06	5067.57	4533	10.66	8.56
WELL #2 6 MONTH AVG.	523.8	540	1749	1614	-115.6	272.6	-15.33	0.153
WELL #3 7 MONTH AVG.	163.33	217.99	20.13	49.74	4817.48	7638.70	26.25	28.53
WELL #4 1 MONTH AVG.	241	294.5	81.2	85.74	6085	6918.64	18.88	18.21

Ball Lift Assembly Results

Plunger Lift with Ball Lift Assembly	START OIL BBLS/M	END OIL BBLS/M	START GAS MCF/M	END GAS MCF/M	START PAYOUT PER MONTH	END PAYOUT PER MONTH	NET (LOSS)
WELL #1 7 MONTH AVG.	173	193.4	5067.57	4533	$25,875.66	$25,555.23	(320.43)
WELL #2 6 MONTH AVG.	523.8	540	-115.6	272.6	$32,317.69	$34,448.95	$2,131.26
WELL #3 7 MONTH AVG.	163.33	217.99	4817.48	7638.70	$24,529.91	$34,196.14	$9,666.23
WELL #4 1 MONTH AVG.	241	294.5	6085	6918.64	$33,145.19	$38,961.95	$5,816.76

Note: Economics base on 2.980/MCF and $62.29/BBL.

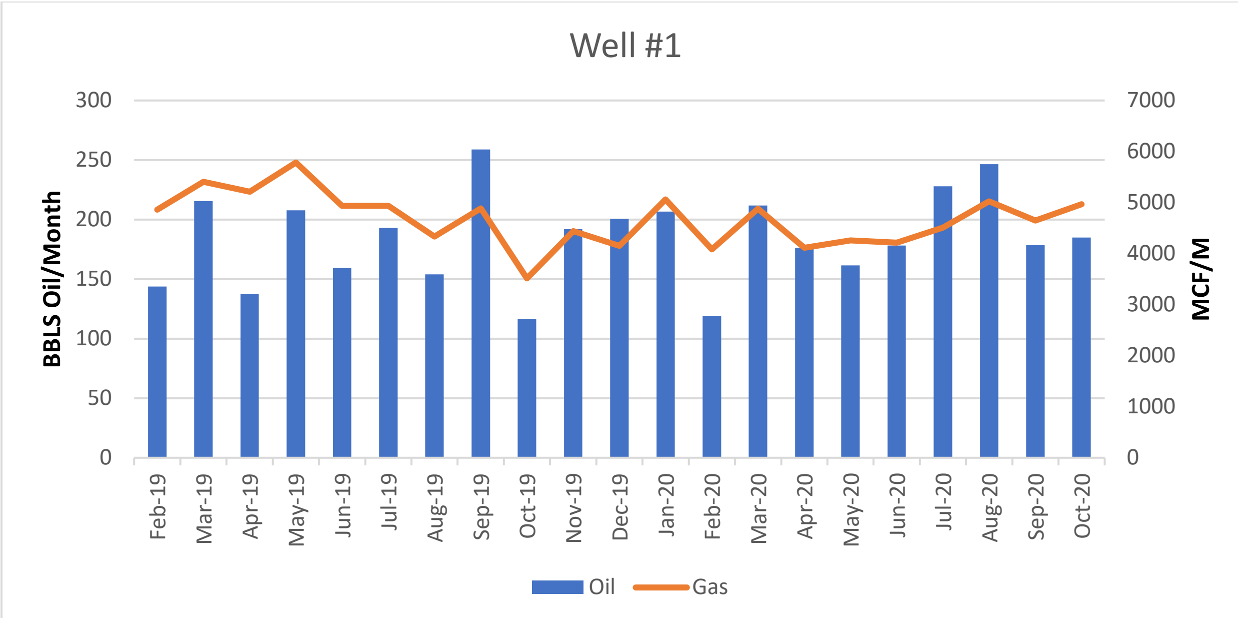

Figure 1 Well #1

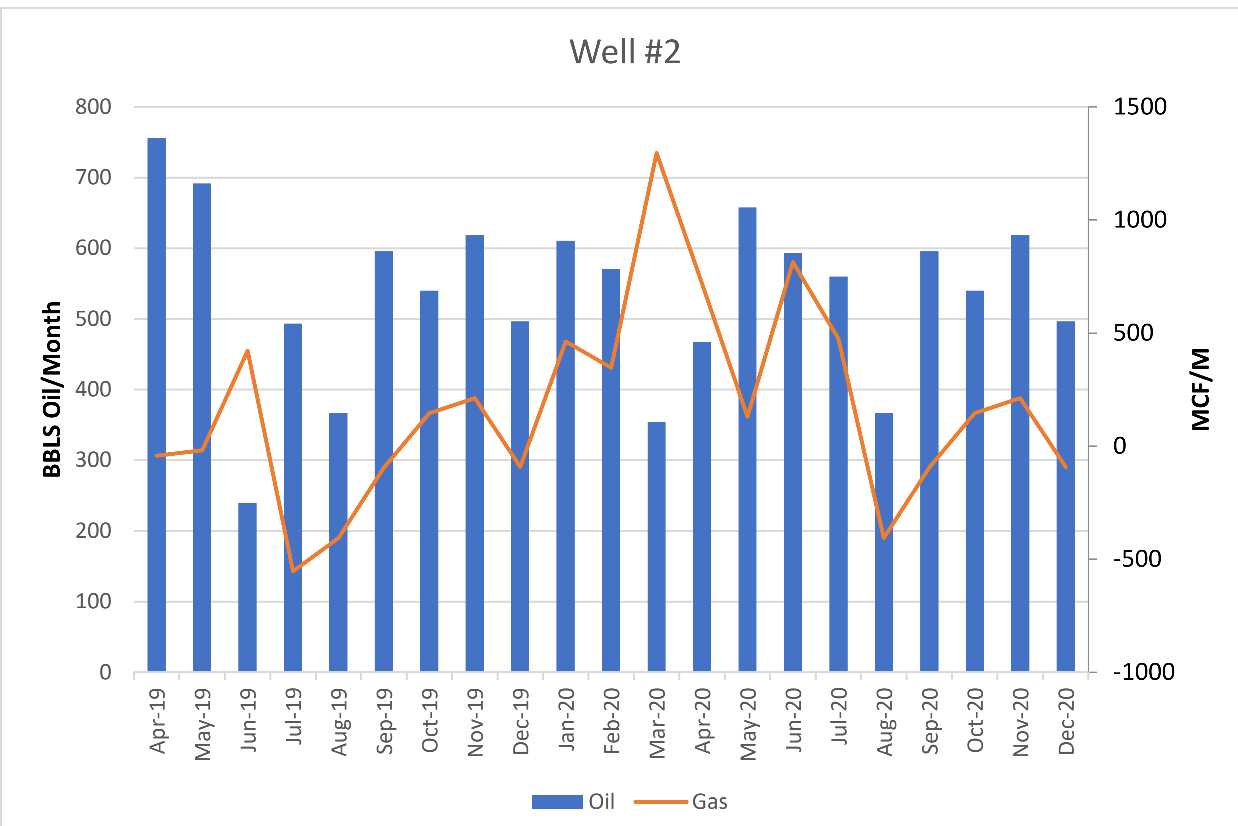

Figure 2 Well #2

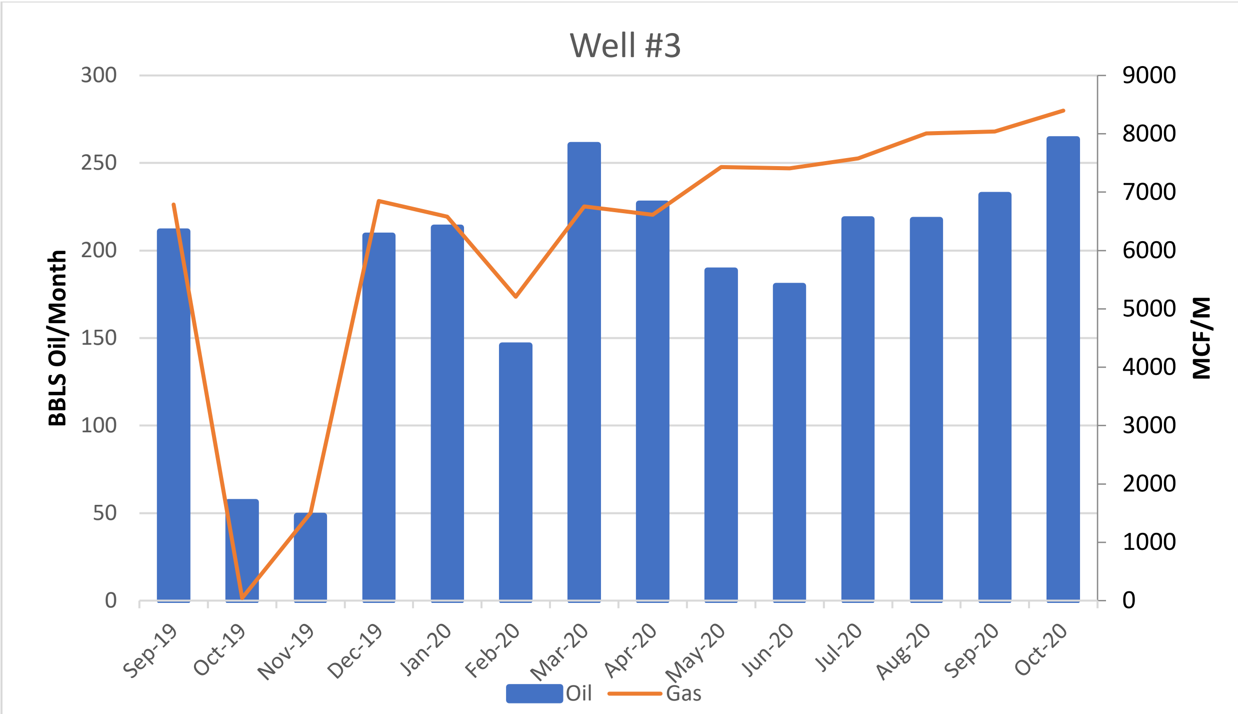

Figure 3 Well #3

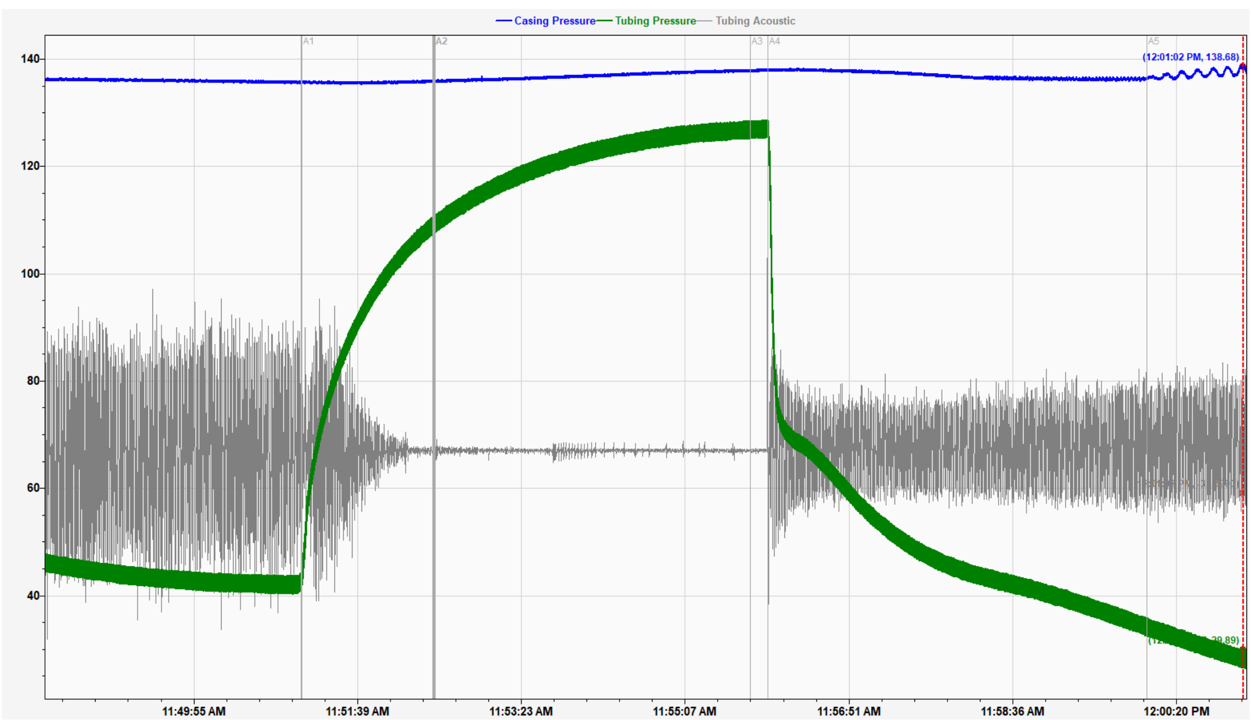

Figure 4 Echometer Plunger Tracking - A1-Valve Closes, A2 – Plunger sleeve contacts ball lifting assembly and continues to move downhole due to liquid stacking on it, A3 – Plunger on bottom, A4 – Valve opens (unloading), A5 – Max injection on 400MCFD rate, slowed down injection valve

Figure 5 Ball and hollow sleeve

Figure 6 Ball lifting device

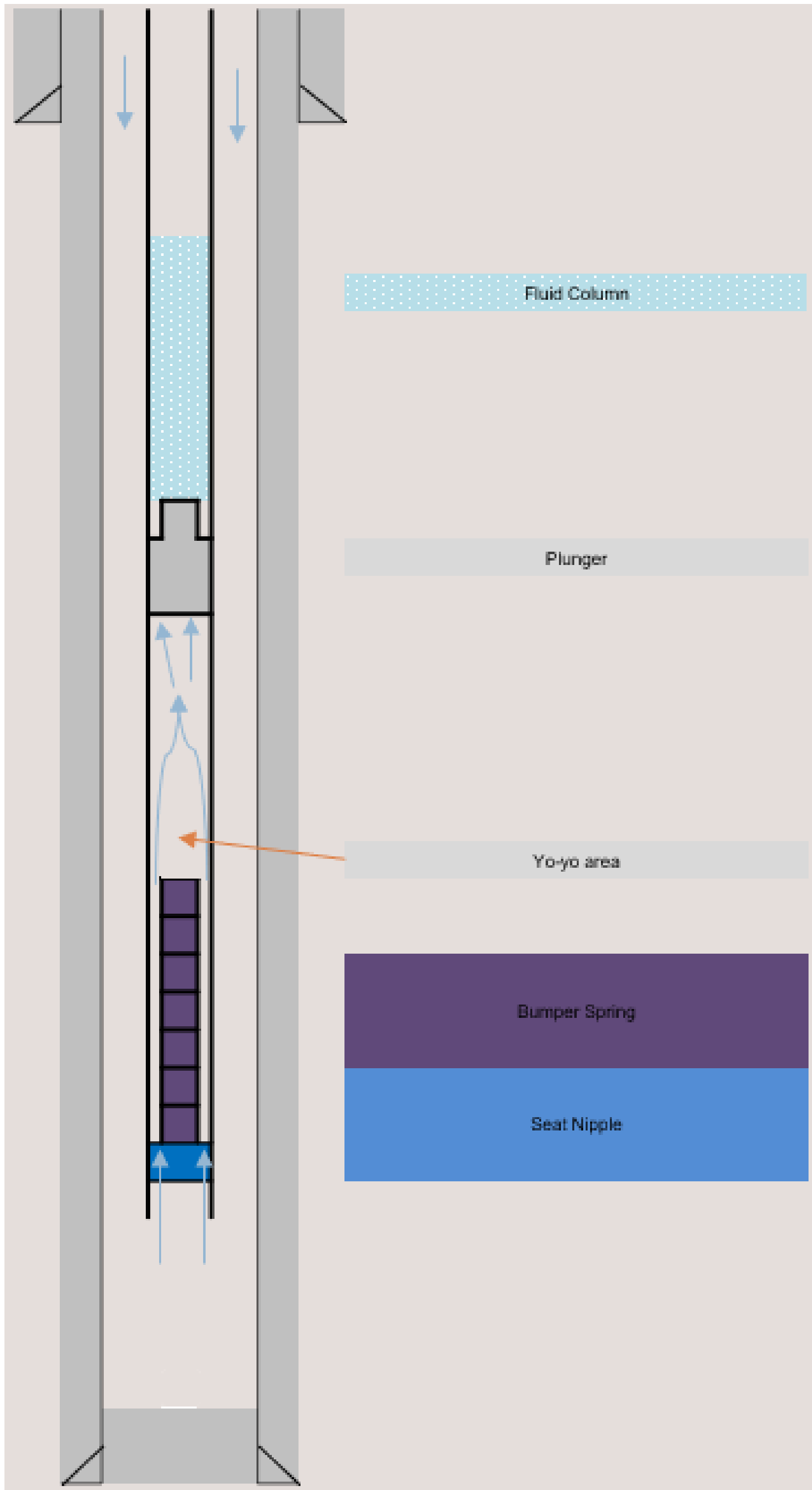

Figure 7 Light blue arrows indicate gas injection down casing