CONTROLLING SAND FLOW BACK IN ESPs WITHOUT LIMITING FLUSHING OPERATIONS THROUGH THE TUBING. FIELD APPLICATIONS IN THE PERMIAN BASIN

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ABSTRACT

This paper introduces a technology for handling solids above the discharge of the ESP pump that increases the run time of the well and prevents premature failure due to plugging or damage to the pump parts thus contributing to the reduction of carbon emissions and environmental impact. Additionally, the new technology was engineered to allow fluid injection through the tubing and its components can be dissembled after pulling it, providing the production engineers with valuable information about the downhole conditions.

The new device used to control the sand above the discharge of the pump was designed with the fundamental purpose of controlling the sand, allowing injection from the surface through the tubing and allowing the inspection and repair of its components after pulling it out of the well. The sand regulation system allows flow rates up to 15,000 BPD and has handled sand volumes up to 23,000 mg/L. While the internal mechanism that allows the control of solids and the injection through the tool is designed to allow up to 8 BPM of direct injection while maintaining a surface pressure of less than 600 psi.

The operational and performance advantages of this device have allowed its successful installation several wells in the Permian Basin. After the installation, the run times have maintained high values, thus reducing the interventions to the wells and the replacement of the pumping equipment, thus reducing the carbon footprint of each one of the wells where this technology has been run. Additionally, the sensor variables have remained stable, which contributes to a higher cumulative production compared to periods where the pump was off for long periods, or the wells were under maintenance because of sand production. On top of that, each equipment pulled has been inspected and re-used to maximize the investment increasing the NPV of the projects. This new technology is the only one with the ability to protect the ESP against solids during shutdown events, allow flushing operations, and being inspectable and repairable. The use of premium materials, along with a special assembly system make it a tool with a long useful life.

INTRODUCTION

The oil and gas industry has been challenged by the problem of sand production for decades. Sand production can cause significant damage to downhole equipment, including electrical submersible pumps (ESPs). The sand production can cause a wide range of problems in electrical submersible pumps, which are commonly used in oil and gas production. One of the most common issues is the plugging of pump stages, which can reduce the flow rate and overall efficiency of the pump. Sand particles can also accumulate in the intake, reducing the pump's ability to draw in fluid from the wellbore. Another major issue is the potential for broken shafts, which can occur when sand particles enter the pump and cause excessive wear on the moving parts (Figure 1). This can lead to costly repairs and downtime for the well. In extreme cases, sand accumulation can cause the pump to seize completely, resulting in a complete shutdown of the well and significant production losses.

The Delaware Basin, in particular, has been a challenge for operators due to high sand production from fractured wells. Even after the depletion of reservoir pressure, sand continues to flow back, causing problems in the equipment. The traditional method of controlling sand flow involves installing expensive gravel packs or completion screens, which can be time-consuming and may not always prevent sand from entering the wellbore, and in more drastic ways can limit the flow inflow from the reservoir. Another approach involves using downhole desander and production screens that may be effective when are designed properly for the well conditions. As an alternative to the existing technologies and to improve the sand handling capacity of the pump a new technology has emerged to regulate sand flow back and prevent ESP damage. This technology has been successfully installed above ESPs showing promising results, reducing the need for costly interventions, and increasing the overall efficiency of production. In this article, we will explore the benefits of this new technology and its potential to revolutionize the way we manage sand production in the oil and gas industry.

Figure 1 Problems caused by sand on ESPs

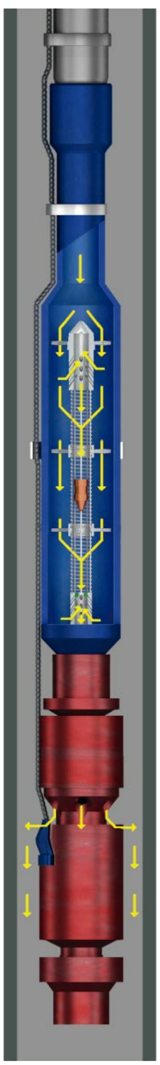
SAND MANAGEMENT TOOL

The Sand Lift is a sand management system installed directly on the discharge of the pump. When the pump is producing fluids, this system does not represent a restriction to the fluid thanks to its large open area in the internal components, table 1 summarizes the total open area depending on the dimensions of the tool.

Table 1 Sand Lift Specifications

Description	Lifting Neck OD (in)	Body OD (in)	Top Connection	Bottom Connection	Capacity of the Cavity (in^3)	Total Open Area (in^2)
Series 350	2-7/8	3.500	2-7/8" EUE Box	2-7/8" EUE Pin	1453.613	293.600
Series 400	2-7/8	4.000	2-7/8" EUE Box	2-7/8" EUE Pin	2060.500	293.600
Series 450	2-7/8	4.500	2-7/8" EUE Box	2-7/8" EUE Pin	2773.082	293.600
Series 550	3-1/2	5.500	3-1/2" EUE Box	3-1/2" EUE Pin	4454.352	368.800

In simulations carried out in computational flow models using up to 8,000 BFPD, pressure drops of less than 10 psi were estimated from the discharge of the pump to the neck section of the tool. Now, when the pump shuts off, the internal system of the Sand Lift works as a flow regulator to the pump. The internal inverted mesh mechanism reduces the amount of solids flowing towards the discharge of the pump, thus avoiding the saturation of the upper pump stages. An important feature unlike other technologies is that the Sand Lift does not have check valve systems, so it does not completely seal the tubing and allows flushing operations through the production tubing to the pump. This feature is especially beneficial in cases where solid control systems are not used below the pump, and it is desired to clean the sand stored in the pump stages. Acid treatments can also be injected without affecting the internal components of the Sand Lift. Figure 2.



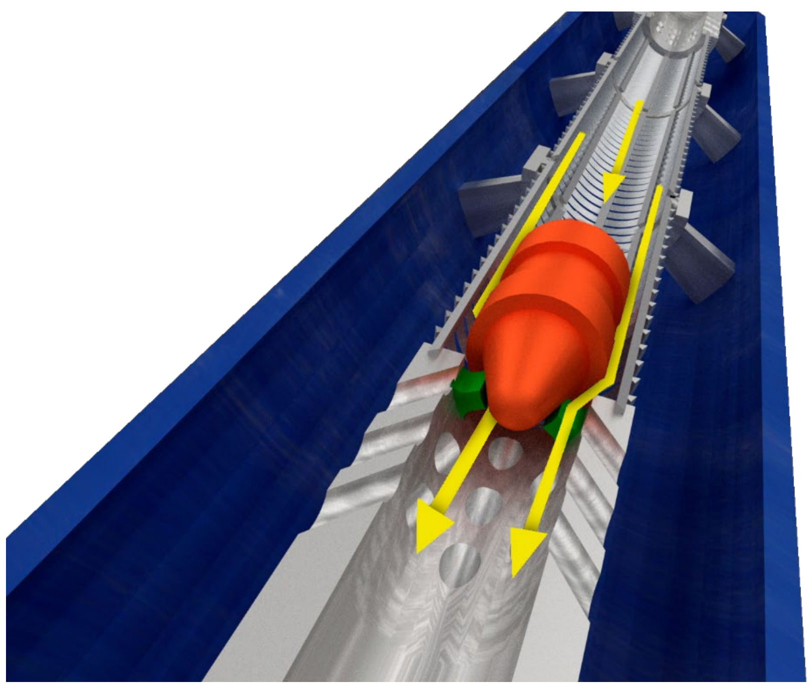


Figure 2 Pump down through the tubing with the Sand Lift

During restart of pump operation, the Sand Lift uses pump discharge pressure as fuel to displace fluid and solids in its chamber. The internal design of the lower ports act as jet ports to sweep and break up any type of solid around. Computer simulation results have shown that the fluid velocity in the bottom jet ports can reach up to 132 in/s. It is important to clarify that this scenario is possible when the pump can reach enough discharge pressure, however, when there are solids in the lower pumps and an adequate discharge pressure cannot be generated, the system will not be able to generate the jetting effect, hence the importance of using combined sand control systems above and below the pump. After the reset, the fluid will move through the inner string and out through the inverted mesh into the tool body and then into the tubing. The inner string has a dart that travels up and down depending on the operation. The main purpose of the dart during the pump restart is to clean out the flow area inside the inner string and avoid sand packaging in the mesh. After the pump restarts, the dart will travel upwards opening the flow area below it and seating at the top section of the inner string in the dart garage. The complete tool operation is illustrated in figure 3.

The general design of this tool was thought to analyze its internal components after removing them from the well in order to provide production engineers with more information about types of solids, amount of solids and severity of downhole problems. Because of this all components of the Sand Lift are inspectable and replaceable without having to cut the tool. This design facilitates the inspection and reconditioning of the tool, which avoids cost overruns for the purchase of new equipment.

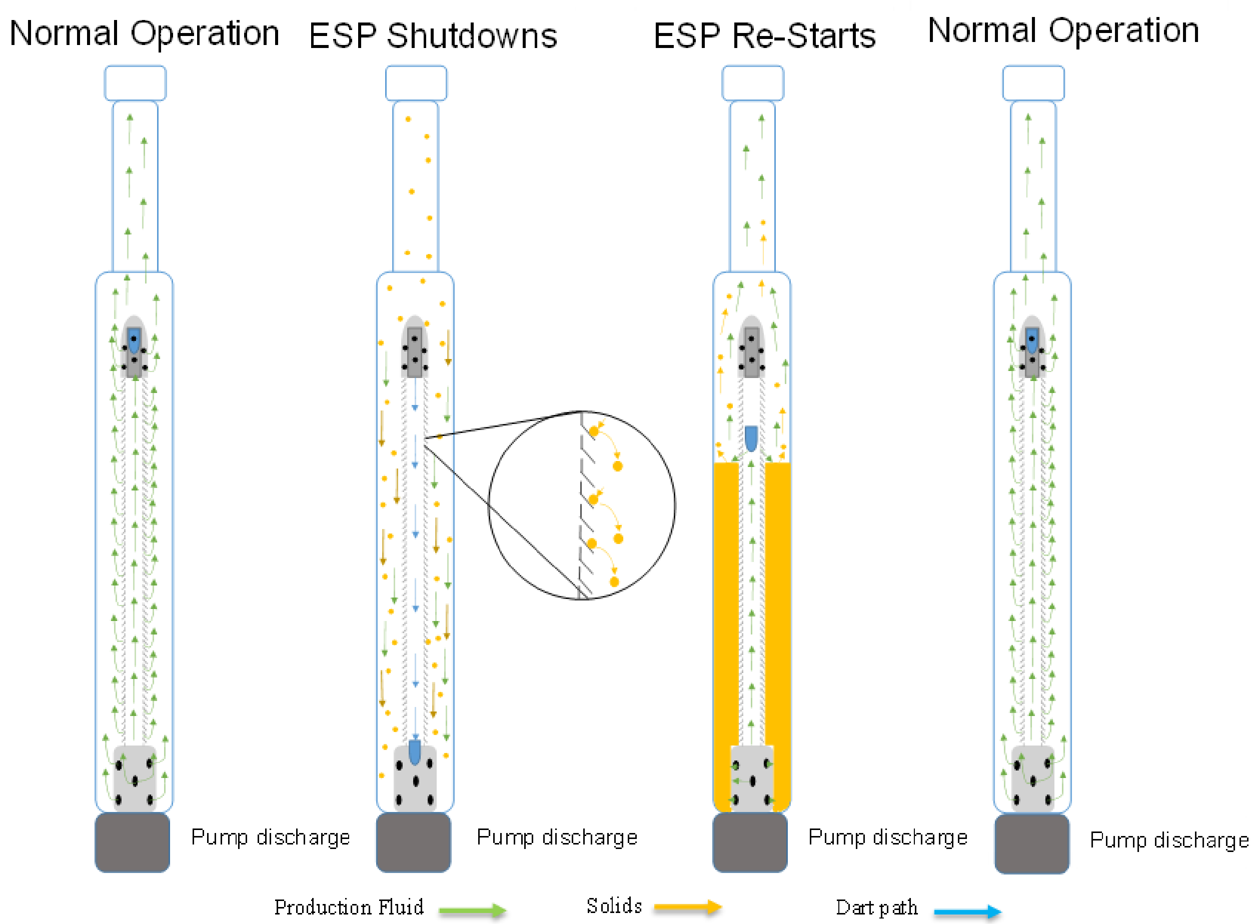


Figure 3 Sand Lift operation

DESIGN AND CONSIDERATIONS

One of the main design variables is the amount of fluid expected and the pressure drop across the tool. This process is done through computational models and requires information such as pump discharge pressure, production flow, fluid properties and flow geometry. The Flow geometry refers to the dimensions and internal design of the Sand Lift's flow channels. The size of the tool largely depends on the factors mentioned above but also on the size of the production casing, the dimensions of the ESP cable and the size of the capillary (if applicable). Figure 3 shows the modeling of downhole tool size in accordance to the casing and cable size. With this information, the pressure drops and flow rate through the tool are determined.

During installation, the tool can be lifted from the neck, which is already properly threaded from the factory, no additional tool is needed to lift or run the Sand lift (Box - Pin). It is recommended to install the Sand Lift directly on the pump discharge without adding spacing joints, this will improve the internal sweep efficiency on the body during pump restart. The banding procedure is performed as shown in figure 4, securing the cable on the neck and the upper and lower section of the body.

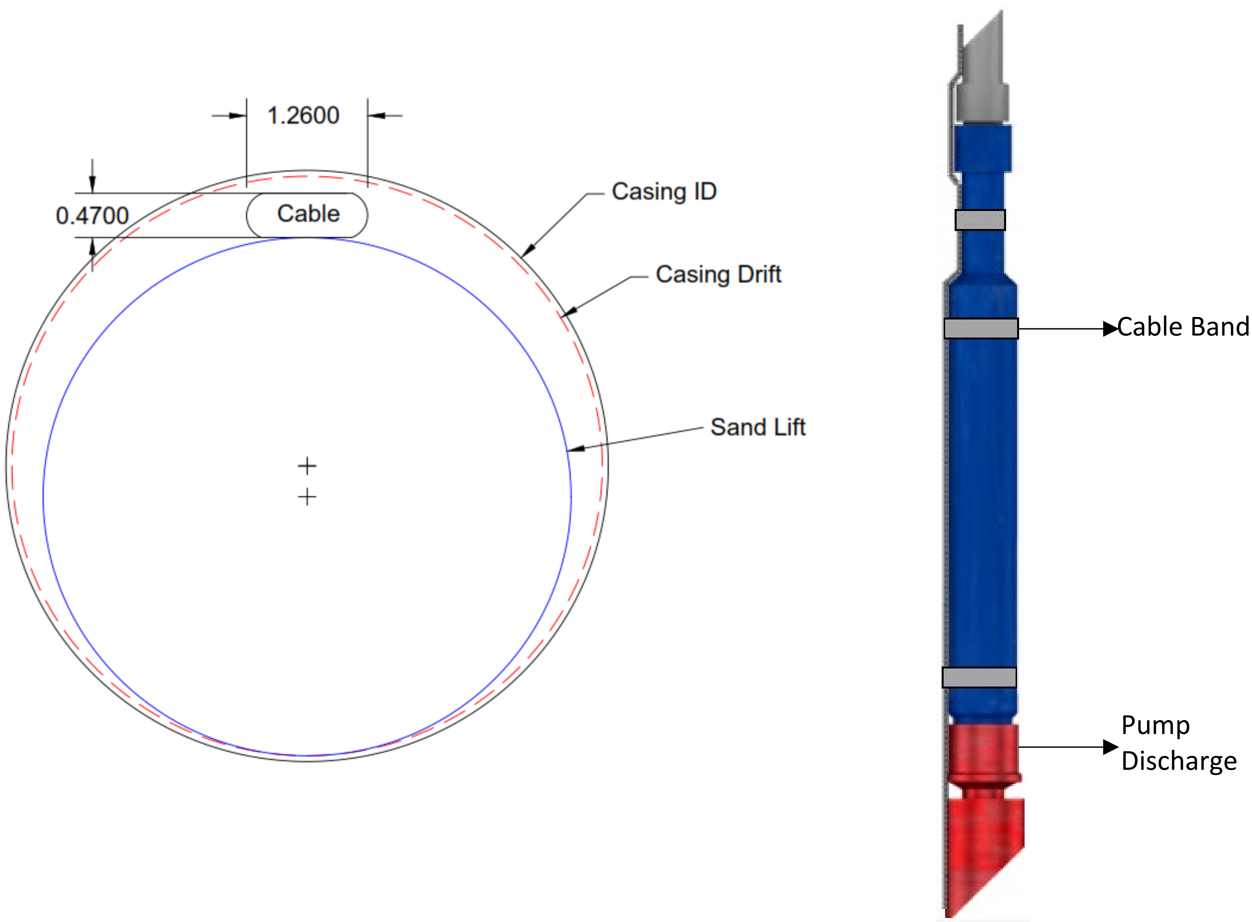


Figure 4. Tool dimensioning and banding procedure

FIELD BACKGROUND

The Sand lift has been installed in the Delaware Basin by ConocoPhillips. The ESPs in this field are all horizontal wells and tend to have a less of drastic depletion curve as some other fields with ESPs tend to have. This field has a history of sand production, with it being typical to always fill up 10 mud joints during the life of an ESP run. This is why sand protection is ran on every ESP and they always install a method of sand fallback protection above the ESP. The casing sizes that are utilized are 5-1/2" and 7" and OSI utilizes two different sand lift sizes for these casing sizes; this being the 350 series for the 5-1/2" casing and 450 series for the 7" casing. General field characteristic are summarized in table 2.

Table 2 Field information

Field Information	
Casing Size	5-1/2"- 7"
Tubing Size	2-7/8"
Pump Depth (FT)	9000-12000'
Oil API	45
Production (BPD)	500-3000
Water Cut %	60-90

CASE STUDIES

There have been 32 sand lifts installed in the Delaware basin by Conoco Phillips. Our first installation was in April 2021 with this being the longest running installation so far (figure 5). All these wells are currently running, with only 5 have been pulled and reinstalled. The tools that have been pulled were then dissembled for inspection and reran, or had parts refurbished and reran as well in other wells.

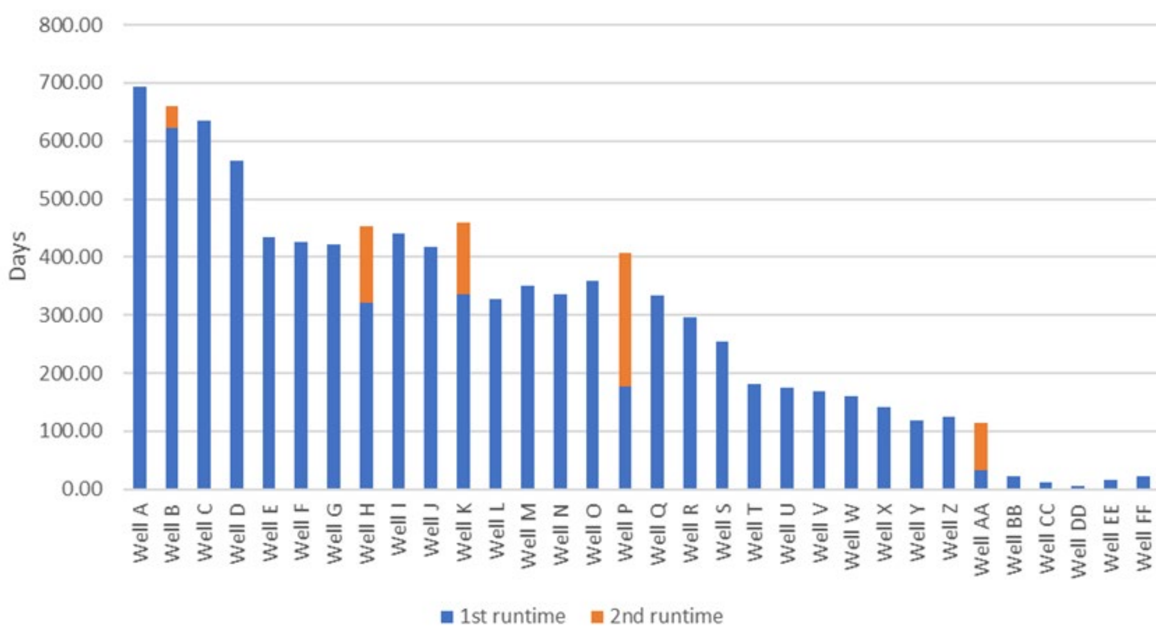


Figure 5 Run time of the wells installed with the Sand Lift

The sand lift was designed to be easily disassembled, allowing for easy access to its internal components. This makes it easier for operators to refurbish the tool when needed. The refurbish process includes examining the screens to determine if they need to be cleaned or replaced. The connection and flow areas are carefully inspected, and samples are collected to determine possible chemical issues. The ability to refurbish the Sand Lift is important because it allows operators to extend the life of the tool and avoid costly replacements. Figure 6 shows different components pulled out of the sand lift and conditioned to be re-run.

Figure 6 Inner string before and after cleaning process

The production ranges of these wells range from 500 to 3000 BFPD. We will be covering two instances where Conoco had to pump back through the tubing, in order to get the well to start producing again, without having to perform a workover. There is often a downside to existing solutions in practice already. Either you may pump down the tubing but are unable to catch the sand before reentering the ESP or you can catch the sand but are limiting, or eliminating the amount of backflushing you are able to perform. In these two case studies, we can show the sand lift allows for backflushing, while still protecting the ESP from sand during non-operating conditions.

Well A

The well was completed in November 2018. We have no prior knowledge of the performance of the well before the sand lift was installed. The sand lift was installed in September 2022 is still running. The current fluid production is 2463 BFPD with a water cut of 91%. The well was producing naturally until the pump stages were forced upward and were eventually stuck in the upthrust position due to solids or scale. In order to get the pumps unstuck, they underwent the following flushing procedure in order to get the pump stages unstuck.

- Pump 55 gallons of general surfactant
- Chase down with a full tubing volume of ~61 bbls of water
- Do not exceed pumping rate of 1.2 bbls/min to avoid damaging ESP
- Increase pumping gradually, with WHP reaching 1000, but keeping below 3000 psi.

Using this procedure, they were able to get the pump stages unstuck and the ESP was able to come back online without burning out the motor or performing a workover operation in order to change out the pump.

Well B

The well was completed in 2017 and the sand lift was installed in January 2022 and is currently still running. The current production 993 BFPD with a water cut of 87%. This well also produced naturally until the pump stages were forced upward and stuck and in the upthrust position due to solids or scale. The same procedure was used on this well and we were able to get the well back online with no flushing limitations from our sand lift.

CONCLUSIONS

- The use of a solids management system above the pump has improved the run life and the performance of ESP pumps, especially if they tend to see many shutdowns during its production run.

- The sand lift was able to reduce costs in two specific cases by protecting the ESP from sand fallback during non-operating instances, while not limiting the ability for a flushing operation. The sand lift was able to prevent a motor burnout or a workover operation.

- Even while the wells producing naturally while the ESP was not operating, the sand lift allowed such little pressure drop through the system that neither the tool nor the ESP were damaged.

- Only five wells have been pulled so far with the root cause not being related to sand. All five sand lifts have been able to be inspected and refurbished and ran in future wells.

- The sand lift refurbish feature allows for easy disassembly and inspection of its internal components, enabling regular maintenance and replacement of the components damaged. This ensures optimal performance after each pulling and extends the tool's life, avoiding costly replacements. No San Lift has been scrapped from the ones pulled.

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