NEW GAS MITIGATION SOLUTION FOR UNCONVENTIONAL WELLS IN ESP (CASE STUDIES IN PERMIAN BASIN)

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ABSTRACT

New unconventional wells have been a huge challenge for ESPs in the Permian Basin because in horizontal wells with high-formation GORs or GLRs, the pumped fluid can cause issues such as gas interference, gas locking, short run life, low production, poor energy efficiency, increased failure rates, shutdowns, so forth. A major problem is gas presence around the ESPs, it causes the motor to rapidly overheat because the gas is incapable of adequately cooling.

For this application, a double stage of gas separation was designed to break the gas slug and avoid gas entrance into ESPs by forcing free gas to go around the shroud and produce through the casing, and the fluid is forced to pass through an additional gas separator (Guardian Shield), this tool helps to separate gas to keep lower motor temperature.

These novel applications help operators to reduced OPEX (operating expense) by minimizing well interventions, decreasing failures in the pump due to overheat, and allowing the ESP to operate in gassy wells with high GLR, stabilizing the production and reducing the unforeseen interruption.

INTRODUCTION

The Electric Submersible Pump (ESP) has been used in the oil and gas industry to handle wells when there are large productions of fluid but when the flow rate of gas exceeds the gas separation capacity, the pump efficiency declines. The experiment conducted by Murakami and Minemura reported that the hydraulic-head degradation and abrupt flow pattern changes as the gas production increases in the pump. Also, with increase of gas inside ESP, the pump rotational speed decreases which drastically reduces the pump efficiency. This also affects the production tests, electric power consumption, and motor temperature and overall, resulting in unstable pumps operation and limiting its full potential.

When downhole gas separators are installed, the performance could still be poor. This stems from little to no evaluation of well conditions before inserting a “template” gas separation tool, to handle liquid production and free gas in the system. This paper summarizes the main methods used for gas separation in ESP as well as theories for identification and prevention of gas problems by choosing an appropriate downhole gas separator. Additionally, some cases studies are included in application of innovative technology applied in the Permian Basin.

UNDERSTANDING GOR/ GLR PRODUCTION

Along the lifespan of the well, the fluid production decreases with the increase in the pump intake pressure along with the increase in gas production. The gas-liquid ratio (GLR) produced in a horizontal well would not represent a problem for the ESP if the fluid is flowing in a steady phase. However, with the time and the well depletion the gas slugs created in the lateral section grow until reach the pump intake. Normally, this happen by cycles but the effect in the productivity of the well are severe. The conditions indicative of gas production is the head developed by the pump as compared to performance curve. The production would show a gradual decrease in fluid production with an increase in the gas flow. This increases the GOR, which would increase the free gas at the pump intake. The article published on Forbes, “The Beginning of The End for The Bakken Shale Play” portrays that the change in GOR not only shows the reservoir energy change but also the fluid production patterns. Rapid increase in GOR indicates partial reservoir depletion while subsequently decreasing GOR suggests advanced depletion accompanied by declining reservoir pressure, declining oil production and increasing water cut as shown in Fig.1. “New ESP Gas Separator for Slugging Horizontal Wells presented at the SPE Electric Submersible Pump Symposium held, 2017 discussed that when ESP's centrifugal forces accelerate liquids, lower density gases lag behind collecting in low pressure areas of pump stages. Eventually with more gas accumulation, one or more vanes become blocked and prevent the fluid flow. This gas locking condition stops liquid flow, which is required to cool the motor, so motor winding temperature spikes. Motor amperage also drops as motor load decreases. When the PID controller fails to control the varying motor/ pump speed, either the ESP shuts down due to motor temperature or the motor overheats and fails catastrophically.

CURRENT SOLUTIONS FOR GASSY WELLS IN ESP:

Reverse Flow Gas Separator:
It works on the principle of gravitational separation by forcing the fluid flow to change direction and allowing free gas to escape into the well's annulus as shown in Fig 1. Well fluid containing free gas bubbles enters the separator through the perforated housing. In the annular space formed by the housing and the stand tube, gas bubbles rise but liquid flows downward. If bubble rise velocity is greater than the countercurrent liquid flow velocity, gas bubbles rise to the top of the separator and escape into the well's annulus through the upper perforations of the separator's housing. Liquid containing a reduced amount of free gas is sucked in by the pickup impeller at the bottom of the separator and is transferred to the ESP pump connected to the top.

Rotary Gas Separator:
Works on the principle that a multiphase mixture, if spun at a high speed in a vessel, is separated to its constituent liquid and gas phases due to the different levels of centrifugal force acting on the liquid and gas particles see Fig 2. The rotational speed is provided by the separator's shaft, connected to the motor, and separation takes place in the body of the separator. Here liquid is forced to the inner wall of the separator while gas is concentrated near the shaft. A flow divider ensures that the separated phases move along different paths and a crossover device directs (a) gas into the casing annulus for venting to the surface and (b) liquid to the pump intake.

Inverted Shroud:
An inverted shroud means a motor shroud open at the top. The shroud is fixed below the pump intake and acts as a reverse flow gas separator, as shown in Fig 3. The ESP unit must be run above the perforations so that the inverted shroud forces well fluids to flow downward in the shroud/unit annular space. Proper design of the shroud diameter ensures that flow velocity here is lower than 0.5 ft/sec required for the gravitational separation of the gas from the liquid. The reverse flow velocity in the annulus between the shroud and the ESP unit can be easily controlled by installing at the top of the shroud a swage of a different diameter than that of the shroud. Use of this type of ESP installation is advantageous in horizontal wells with severe slugging problems because a long-inverted shroud acts as a fluid reservoir that keeps the pump primed in periods when large gas slugs are produced by the well.

Shrouded ESP with Gas Separator and Dip Tube:
In case of greater gas production rates, in addition to the motor shroud, the use of a simple reverse flow gas separator is advised. Here the shroud is installed just above the separator intake holes and vent tubes direct the separated gas in the casing/tubing annulus above the perforations. Often a dip tube is connected to the bottom of the regular motor shroud, as seen in Fig 4. The benefits of this design, as compared to the use of open ended shrouds are the natural separation of the free gas and liquid is greatly improved because of the increased annular cross-sectional area available for downward flow between the casing and the dip tube, also the well fluids can be produced from a restricted section of a vertical or inclined hole where the ESP unit would not pass, and this arrangement can also be used in horizontal wells with the ESP unit run in the vertical section and the dip tube reaching into the horizontal part of the well.

Gas Handler:
A short lower tandem pump with high capacity stages is added below the main pump. It pumps the gassy fluids entering the pump suction and simultaneously compresses the mixture so that the fluid is lifted easier by the main pump. Gas blenders disperse free gas in the liquid phase and the small bubbles created are carried with liquid ensuring no gas lock situation. Again, if large slugs of gas has already entered the pump

where there has not been an efficient separation of gas from liquid, gas handler wouldn't be able to disperse gas bubbles with liquid since enough liquid wouldn't be present.

All the possible alternatives or solutions mentioned before have some limitations, because it didn't have in consideration one of the main factor that is the ESP Motor. The regular set up for gassy wells compromises of lower tandem, Upper Tandem Gas Separator and Gas Handler, because we want to avoid gas in the pump, and there is nothing wrong with that, but we forgot that no matter how many UT Gas Separator we have installed the fluid needs to pass first through the motor and the main reason of the frequently shutdowns is due to gas. It is related more due to overheating, and it is because when the fluid with the free gas pass around the motor, it affects the cooling process of the system causing an incremental of the motor temperature that causes a shutdown.

The inverted shroud -it is a good system to separate the gas because, it increases the fluid velocity on the outside (higher than 0.5 ft/sec) forcing the gas to keep traveling up, while the fluid is coming down inside the shroud creating a gravitational gas separation when the fluids is going to the intake. There are two types of inverted shroud; the first one is assembled from the bottom of the intake up around 30 to 60 ft, where the motor outside the shroud is exposed to the fluid and gas slug, it will cause the same overheat phenomena that was explained previously. The second option is where the motor is inside the inverted shroud. The limitation is related on how the motor is cooled because the fluid comes from the top of the opening shroud straight to the intake, creating static fluid below it that cause an over heat because it is not cooling the motor. This issue could be handled using a recirculating pump that is connected to the port of the gas separator to push fluid down below the motor but based on the amount of fluid and gas that is going through the system the limitation is how much fluid can be circulated, it affects the efficiency of the system. This design has been implemented in different wells some with good results in low GOR/GLR the only issue is more related to scale build up inside the shroud due to the changes of temperature and pressure.

NEW GAS MITIGATION TECHNOLOGY

The Guardian Shield ™ is an amalgamation of the different technologies, re-engineered to solve the root cause to deal with gas slug and free gas entrance around and into the pump to optimize highest well production potential. It is designed meticulously to utilize accurate gas separation principles and condition the fluids to achieve maximum separation efficiency before it enters the pump. Guardian Shield ™ not only conditions the fluid inside the tools but strategically utilizes entire wellbore geometry to implement gas separation. This way the fluid is agitated with various stages of gas separation before entering the pump intake. This tool is used in conjunction with shrouded ESP, UT Gas Separator, Dip Tube and re-designed static/centrifugal gas separator with Dual Flow system to increase the separation per stages.

How to Shroud the ESP:
The lower tandem of the ESP is replaced with an appropriate sized intake section below the UT gas separator. The motor also must be of an appropriate size giving minimal annular area between the Motor O.D. and casing drift. The shroud is clamped above the intake section with an adaptor clamp encapsulating the ESP system from the top of the intake down, covering the seals, motor a sensor, it will work as a shield allowing the shroud to work as a shield protecting the motor from the gas slugs. Some of the typical size used for encapsulating the pump based on the casing size and motor OD are showed in table 1.

OPERATING PRINCIPLES OF THE GUARDIAN SHIELD™

The Guardian Shield combines the principles of downhole gas separation to create a more efficient separation process. As discussed in the previous sections, there are many limitations that reduce both, the capacity and the efficiency of the separators available in the industry. With the development of this new technology, it is sought to eliminate these barriers to promote the productivity of the wells. The principles found in its operation are:

- Bernoulli principle
- Venturi effect
- Coalescence effect
- Pressure drop
- Gravitational force
- Agitation

The process starts when the fluid flows upwards from the perforations and downward from the fluid column. In the first stage, the shroud restricts the flow of fluid to the pump and directs it towards the lower part of the assembly where the Guardian Shield is installed. This fluid flowing downward creates a natural gas separation that is directly proportional to the annular area between the casing and the production tubing. In the second stage, due to the outer geometry of the separators the fluid passes through the annular area between the ID of the casing and the OD of the separators that decrease and increase the velocity of the fluid, creating a Bernoulli principle in the neck sections of the separator, which helps to the release of gas from the fluid. The mechanism is illustrated in figure 5. After passing through this outer section, the fluid will enter through the V-wire screen intake that will help the coalescence of the bubbles that try to enter the system (Figure 6) while ventilating the larger ones towards the annular space.

The effect of coalescence creates bubbles of greater diameter that move more easily and with greater speed through the fluid, which results in a more effective separation. When the fluid passes through the intake into gas separation section, the well stream is led into a space of sufficient capacity, then liquids, being denser than gas, flow downward due to gravity, but gas bubbles tend to rise (figure 5). While the fluid enters the gas separator section as well as passes from one gas separator section to another, creates an effect of passing from a small diameter to a bigger one causing a Venturi effect to the "downstream" which produce the expansion of free gas that travels with the fluid due to the pressure change, and then the gas by density difference ascends again, to be out the system through the venting area. If downward liquid velocity is lower than the terminal velocity of the gas bubbles, the resultant gas velocity is directed upward, and the gas phase continuously rises compared to the liquid phase. High liquid velocities, on the other hand, results in the gas bubbles being taken along with the liquid and no separation of the phases takes place. For an effective gas separation, therefore, flow velocity of the liquid must be kept below the typical bubble rise velocity of 0.5 ft/s. Additionally, while the fluid is flowing through separation chambers, it will pass through the Dual Flow System™, an innovative and essential component that simulate the impeller of the ESP producing the necessary turbulence to promotes the coalescence of the gas bubbles making the migration easier toward the outlet points.

After pass through the separation sections, the fluids enter through the last stage of gas separation into the Vortex Gas Shield, that creates a centrifugal effect separating the gas bubbles before the fluid enters into the dip tube (figures 5 and 7). When the fluid path enters the last separation section before entering the dip tube, the fluid is conditioned in such a way that it maintains its velocity of 1 ft/ s. When the fluid enters the dip tube with this velocity the pressure drop forces the free gas to be back in solution and enters the dip tube as solution gas. The same velocity maintained through the dip tube helps the motor to get an effective cooling process and avoid shutdowns due to overheat in the system. The overall operation of the Guardian Shield is illustrated in figure 8. Basically, this tool is composed of 4 main section:

- Intake section
- Separation section
- Vortex Gas Separator
- Dual Flow System™

CASE STUDY: PARKER JE 5

Well Conditions

Parker JE 5 is in the Permian Basin of Pecos County, TX. This is a horizontal well with with top of perforations at 8581 ft. The casing on this well is 5-1/2” #17 making the casing drift of 4.767 inches, while the tubing is 2-7/8”. The average fluid production on this well is of 1000 BFPD consisting of 60 BOPD and 940 BWPD. The gas production is of 650 MCFD making a GOR of 12,500 SCF/STB and GLR of 650 SCF/STB. The well conditions are as shown in Table 2.

This well had a history of high motor frequency showing a continuous fluctuation in between 47-65 hz portraying large variation in motor current from the presence of lower density fluid i.e. free gas. The motor temperature ran a high of 280 F hotter than normal motor temperature indicating presence of gas. While the pump intake pressure had a high of 752.5 psi indicating gradual decrease in fluid production and increase in gas; resulting in requirement of larger energy to load the fluid into the pump intake (as shown in Fig. 9).

The well geometry before installation of Guardian Shield consisted of ESP unit with 456 motor series of O.D. of 4.56" and intake 400 series into a casing 5-1/2" with a drift of 4.767" (fig. 10a). An intake section of 338 series with motor 375 series with 3.75" on ESP was recommended with a shroud of thickness 0.15". This gave a linear distance of 0.195" on each side between shroud ID and pump motor O.D. and 0.1925" Recommended well geometry is shown in fig. 10b.

After OSI'S GUARDIAN SHIELD Installation

The well behavior was observed to change completely after the installation of Guardian Shield. The most notable changes for evaluation of effectiveness of Guardian Shield's mitigation system are illustrated in figure 11:

1. Motor temperature is directly proportional to gas production and fluctuates with the increase/ decrease in temperature. After OSI's tools installation, motor temperature has been stable for a longer period of days in between 135.5 F to 146 F compared to constant fluctuation between 179.3 F and 292.6 F. Average motor temperature has almost dropped by almost 100 F after Guardian Shield installation.
2. For every 18F of operating temperature increase, the life of insulation material is reduced by 50%. Hence, maintaining a constant temperature increases the life of the motor.
3. Temperature is proportional to motor frequency. After tools installation, the fluctuation on the motor frequency has changed. Motor frequency has been constant at an average of 45.12 hz, whereas the last month before installation of tools, a dramatic fluctuation was observed at 65 hz causing the ESP to shut down after every several hours. Motor frequency has been observed to remain stable lately, which prevents ESP shutdown, increasing pump efficiency in last month
4. Less free gas at the pump intake means less effort and power requirement to lift the fluid volume.
5. Overall, OSI's tools have increased pump efficiency leading to increase in oil production.

<u>CASE STUDY: COUSIN WILLARD 450 4H</u>

Well Conditions

Cousin Willard 450 4H is another well located in Permian Basin of Yoakum County, Texas. This is a horizontal well drilled through the formations of Salt, Tansil, Yates, 7 Rivers, Grayburg and Sand Andres with a total depth of 9820 ft. having a lateral of about 4000 ft with perforations from 5600' – 9762'. This well has a 5-1/2" 20# casing with drift 4.653" and a 2-7/8" tubing. The maximum production of this well was 1700 BFPD with a GOR of 3502 scf/stb. The gas volume expected to produce was 800 MCFD. Other conditions are summarized in table 3.

The main problem with this well was the presence of free gas in the pump intake. The well had an average intervention time of 3 months with a history of work over due to cleanouts and pump change. The sensor parameters showed a motor temperature to be an average of 182.3 F with a maximum temperature of 279.9 F. Elevated temperatures indicated a high presence of free gas due to heat transfer in presence of gas that would be relatively slower in presence of liquid. The pump intake pressure drastically increased since July 2017 portraying a highest of 600 psi. The presence of high free gas around the pump is the reason of variables showing high variation; this increases the efforts made by pump as well as power demanded to produce the fluid. Figure 12 shows the variation of the sensor parameters.

The well geometry recommended for the installation of Guardian Shield consisted of ESP unit with 375 motor series of O.D. of 3.75" because the casing drift of 4.653". An intake section of 338 series with 338 seals on ESP for install a shroud of thickness .15". This gave a linear distance of 0.195" on each side between motor O.D and shroud ID and 0.1085" between the casing drift and the shroud OD. Recommended well geometry is shown in fig 13.

After OSI'S GUARDIAN SHIELD Installation

The changes in the pump performance were notable since the installation of the Guardian Shield (fig. 14):

1. Motor temperature is directly proportional to gas production and fluctuates with the increase/ decrease in temperature. After OSI's tolls installation, motor temperature not only has been stable for a longer period else it has kept a lower value passing from 193 F to 119 F after the installation.
2. The reduction and balance in the motor temperature will reduce the risk of problems due to scale deposition around the motor and the pump intake.
3. The pump intake pressure has been reducing since the installation of the tools. This could mean, a reduction in the fluid column due to a better efficiency of the pump.
4. The increasing in the motor voltage is caused by the increase in the frequency of the pump. This behavior is normal when the motor frequency is increased to get more production of fluid
5. Less free gas at the pump intake means less effort and power requirement to lift the fluid volume for this reason even when the motor frequency was increased the motor current has maintained stable without severe oscillation.
6. In general, an excellent performance is showed in the sensor parameters, proving the affectively and capacity of the Guardian Shield combined with the ESP installation

<u>CASE STUDY: SOA SE 0041WB – NEW WELL</u>

Well Condition
SOA SE 0041 WB is a newly drilled well in the Permian Basin, TX. This is a horizontal well with a pump depth of 9000 ft. The casing on this well is 5-1/2" #20 making the casing drift of 4.653", while the tubing is 2-7/8". The average fluid production on this well is of 1000 BFPD with a 65% of water cut. The gas production is of 335 MCFD making a GOR of 3000 SCF/STB. Other well conditions are summarized in table 4.

With the new well being drilled, the main problem with this well was considered the control and separation of free gas for ESP to produce fluids to its maximum potential without hinderance of gas.

The well geometry recommended for the installation of Guardian Shield consisted of ESP unit with 375 motor series of O.D. of 3.75" because the casing drift of 4.653". An intake section of 338 series with 338 seals on ESP for install a shroud of thickness .15". This gave a linear distance of 0.195" on each side between motor O.D and shroud ID and 0.1085" between the casing drift and the shroud OD. Recommended well geometry is shown in fig 13.

After OSI'S GUARDIAN SHIELD Installation
The most notable's changes to evaluate are (fig. 15):
1. The well was completed with a ESP and the Guardian Shield™. From the beginning of the production period the well has reduced more than 1000 psi the PIP while the pump parameters have been kept stable and in normal values.
2. Average motor temperature has been 166 F with a max. temperature of 171.8 F which is a low value considering the pump depth and the volume expected. On the same way the fluid temperature reported was 154.9 with no changes in the trend.
3. Even with a low motor frequency, the well has reduced the fluid column with no problems in the pumping system.
4. Motor frequency has been observed to remain stable lately which prevents ESP shutdown, increasing pump efficiency in last month.
5. Overall, Guardian Shield have maintained a consistent performance in new well.

<u>CONCLUSIONS</u>

- A methodical downhole gas separator plays a key factor for not only separation of free gas but also for maximum efficiency of ESP. In the case studies was noticed that the previous performance although without interventions was highly affected by the shutdowns of the pump. All this time off line represents loss of production and less incomes for the project. With the installation of the Guardian Shield this phenomenon was reduced significantly preventing damage in the ESP components and loss of productivity.

- Increases in the capital expenses is a very common problem when the high temperature and over effort affect the ESPs. Controlling the harmful effects of the gas, reduces the investments in asset (new pumps, part damaged) and increase the net present value of the oil production projects.
- There is not standard design to optimize the ESP performance, however the proper combination of the downhole gas separation principles is the best option to reduce the poor performance of the ESP in very gassy wells. This is the main advantage of the Guardian Shield, because it's a tool with multiple separation principles and very basic requirements for installation.
- An encapsulated system keeps the motor cool keeping the operation of the system stable. The design of the shroud should be appropriate in accordance with O.D. of the casing and Motor O.D. of the pump.
- The fluid velocity needs to be engineered of less than 0.5 ft/ sec and hence a gas separator with varying diameters creating continuous pressure change and agitation should be designed. In addition, the design must consider the speed changes before entering the separator due to the external geometry of the separation bodies. The designer must include the limitations of the casing to use it as a strategic design advantage.
- Along with that, the length of not only the gas separator but the dip tube should be long enough to give enough retention time for separation of gas from fluid by gravitation; creating minimal pressure drop before entering the dip tube through the pump. Additionally, the capacity of the separator must be design according to the pump capacity.

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Table 1. Casing Size, Shroud O.D., Max Motor O.D.

CASING SIZE	Max. SHROUD O.D.	Max. MOTOR O.D.
9-5/8”	7-5/8”	5.62”
7-1/2”	5-1/2”	4.56”
5-1/2”	4-1/2”	3.75”

Table 2. Well Conditions - Parker JE 5

WELL CONDITIONS		
CASING	5-1/2	IN
CASING DRIFT	4.767	IN
TUBING	2-7/8	IN
AVERAGE FLUID RATE	1000	BFPD
AVERAGE OIL PRODUCTION	60	BOPD
AVERAGE WATER PRODUCTION	940	BWPD
AVERAGE GAS FLOW	650	MCFD
WCUT	94	%
GOR	12500	SCF/STB
GLR	650	SCF/STB
API	39	
PUMP DEPTH	8370	FT
FLAP	1300	FT
TOP OF PERFS	8581	FT
THP	350	PSI
CHP	0-500	PSI

Table 3. Well Conditions – Cousin Willard 450 4H

WELL CONDITIONS		
CASING	5-1/2	IN
CASING DRIFT	4.653	IN
TUBING	2-7/8	IN
AVERAGE FLUID RATE	1470	BFPD
TARGET OIL PRODUCTION	170	BOPD
TARGET WATER PRODUCTION	1300	BWPD
GAS FLOW	510	MCFD
WCUT	88	%
GOR	3000	SCF/STB
GLR	347	SCF/STB
API	32	
PUMP INTAKE	4777	FT
BOTTOM PUMP	4855	FT
LL	3677	FT
TOP OF PERFS	5600	FT
KOP	4800	FT
THP	350	PSI
CHP	150	PSI

Table 4. Well Conditions – SOA SE 0041WB

WELL CONDITIONS		
CASING	5-1/2	IN
CASING DRIFT	4.653	IN
TUBING	2-7/8	IN
AVERAGE FLUID RATE	1000	BFPD
MAXIMUM FLUID RATE	2000	BFPD
AVERAGE GAS FLOW	335	MCFD
WCUT	65	%
GOR	3000	SCF/STB
SETTING DEPTH	9000	FT

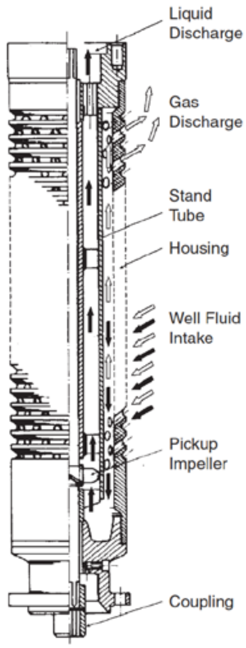

Figure 1. Reverse Flow Gas Separator

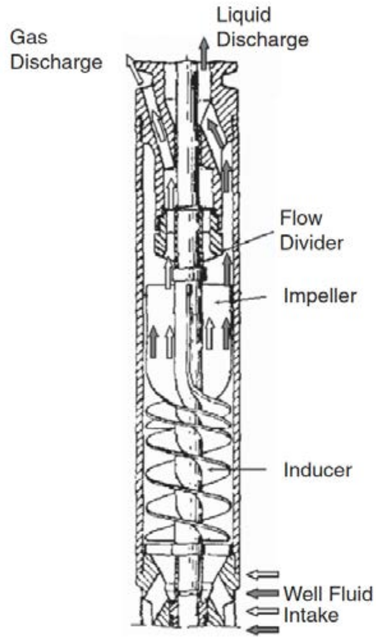

Figure 2. Rotary Gas Separator

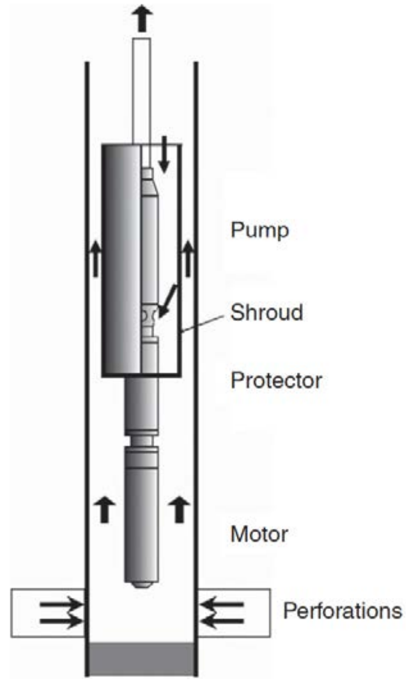

Figure 3. Inverted Shroud

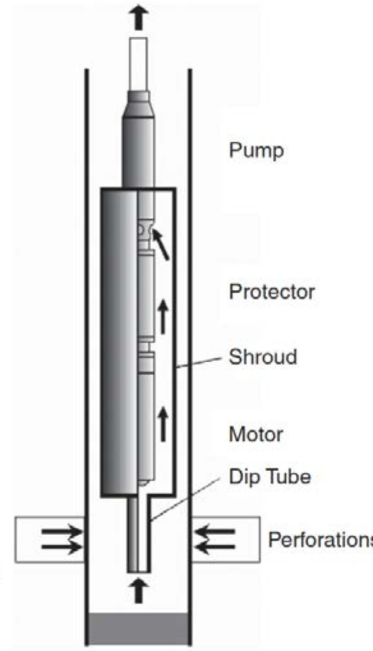

Figure 4. Shrouded ESP with Gas Separator and Dip Tube.

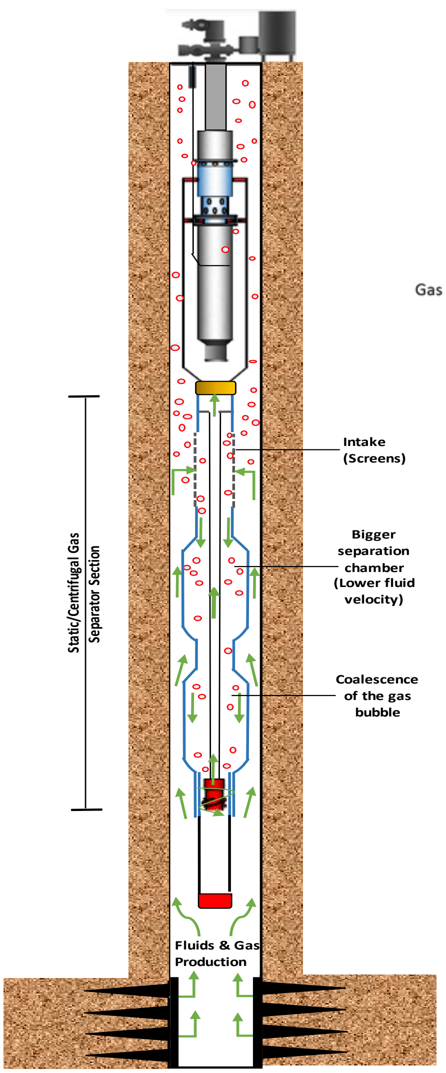

Figure 5. Operation of the Guardian Shield™

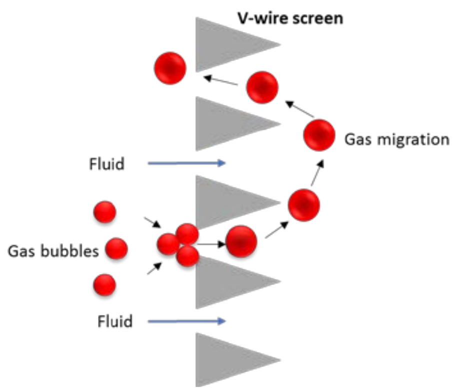

Figure 6. Coalescence effect in the intake

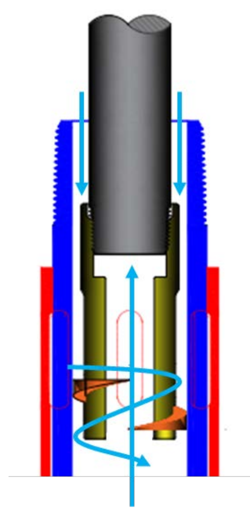

Figure 7. Vortex Gas Shield

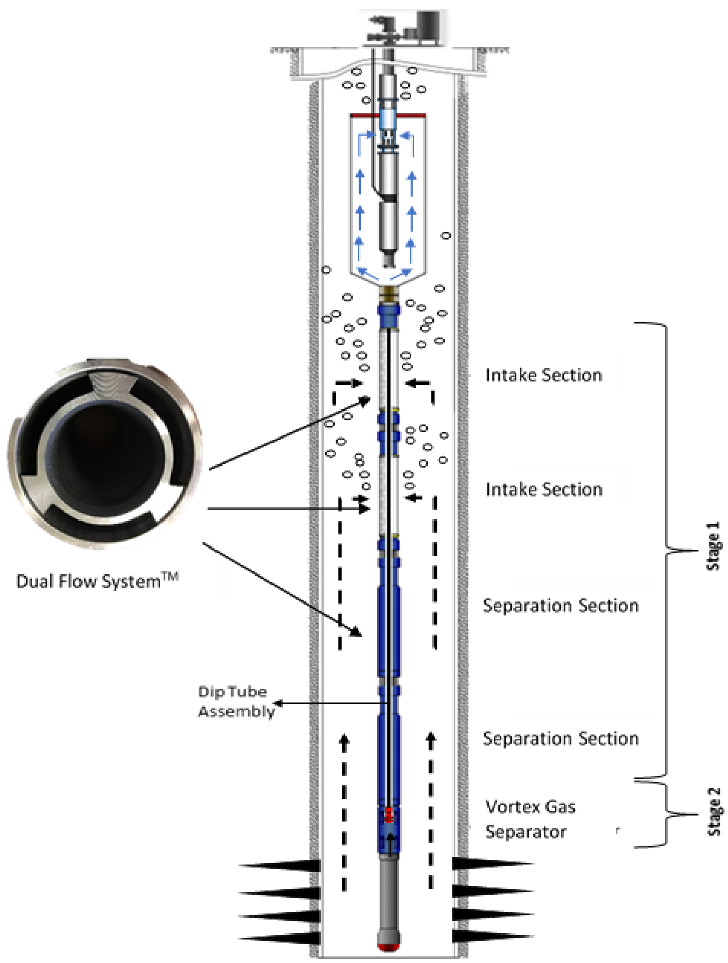

Figure 8. Main components of the Guardian

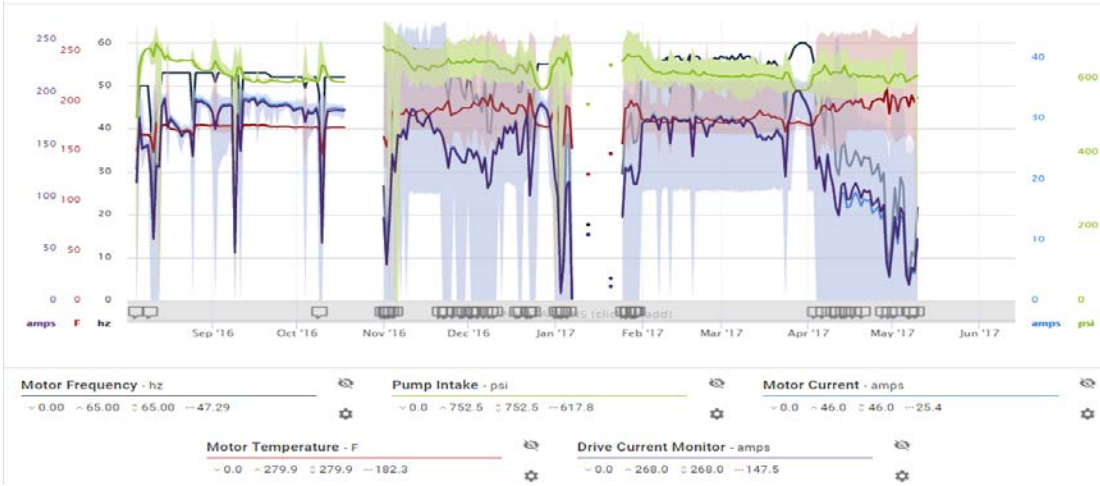

Figure 9. Sensor parameters BEFORE Guardian Shield Installation - Parker JE

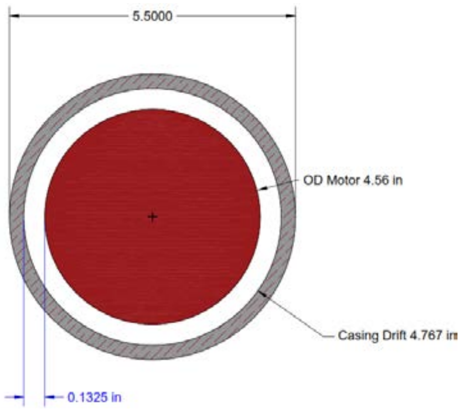

Figure 10a. Well geometry BEFORE Guardian Shield installation – JE 5

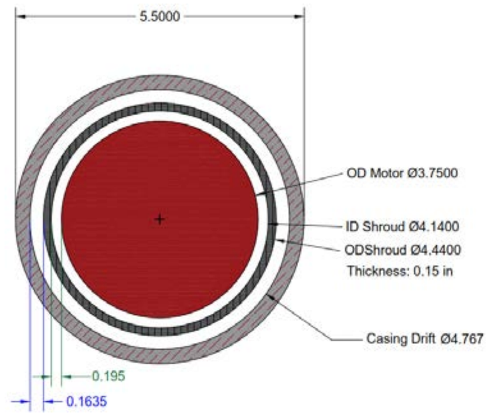

Figure 10b. Well geometry AFTER Guardian Shield installation – JE 5

Figure 11. Sensor parameters AFTER Guardian Shield Installation - Parker JE 5

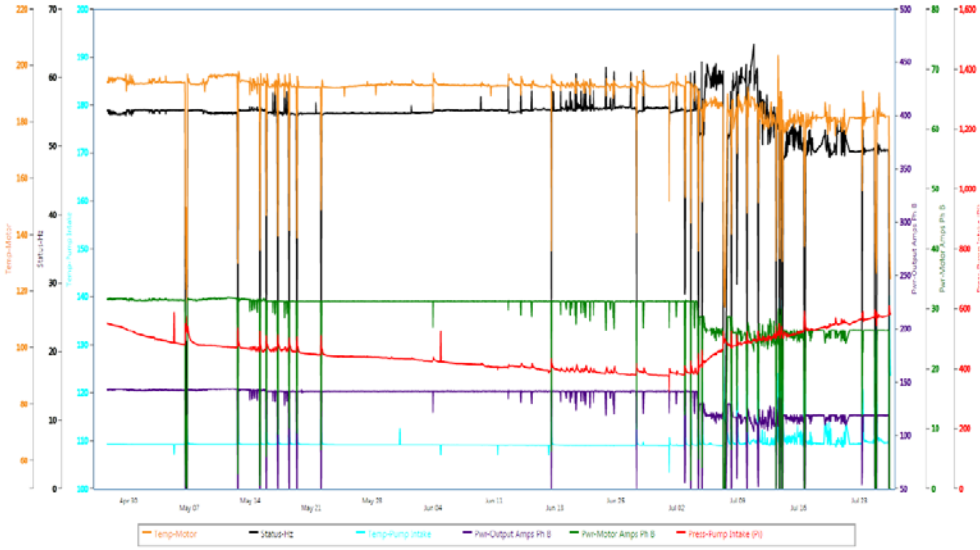

Figure 12. Sensor parameters BEFORE Guardian Shield Installation – Cousin Willard 450 4H

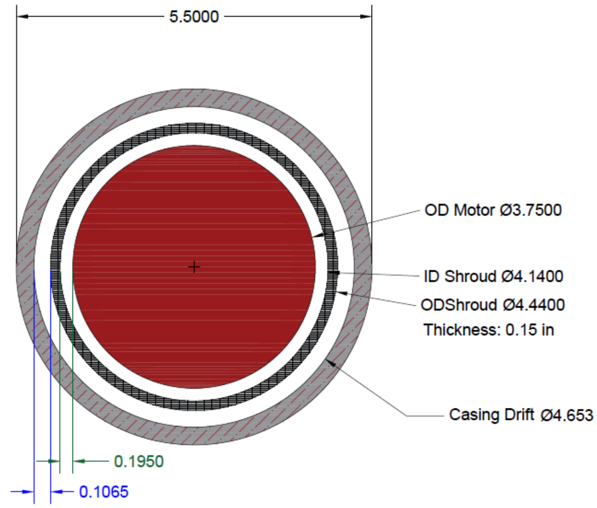

Figure 13. Well geometry recommended- Cousin Willard 450-4H

Figure 14. Sensor parameters AFTER Guardian Shield Installation – Cousin Willard 450 4H

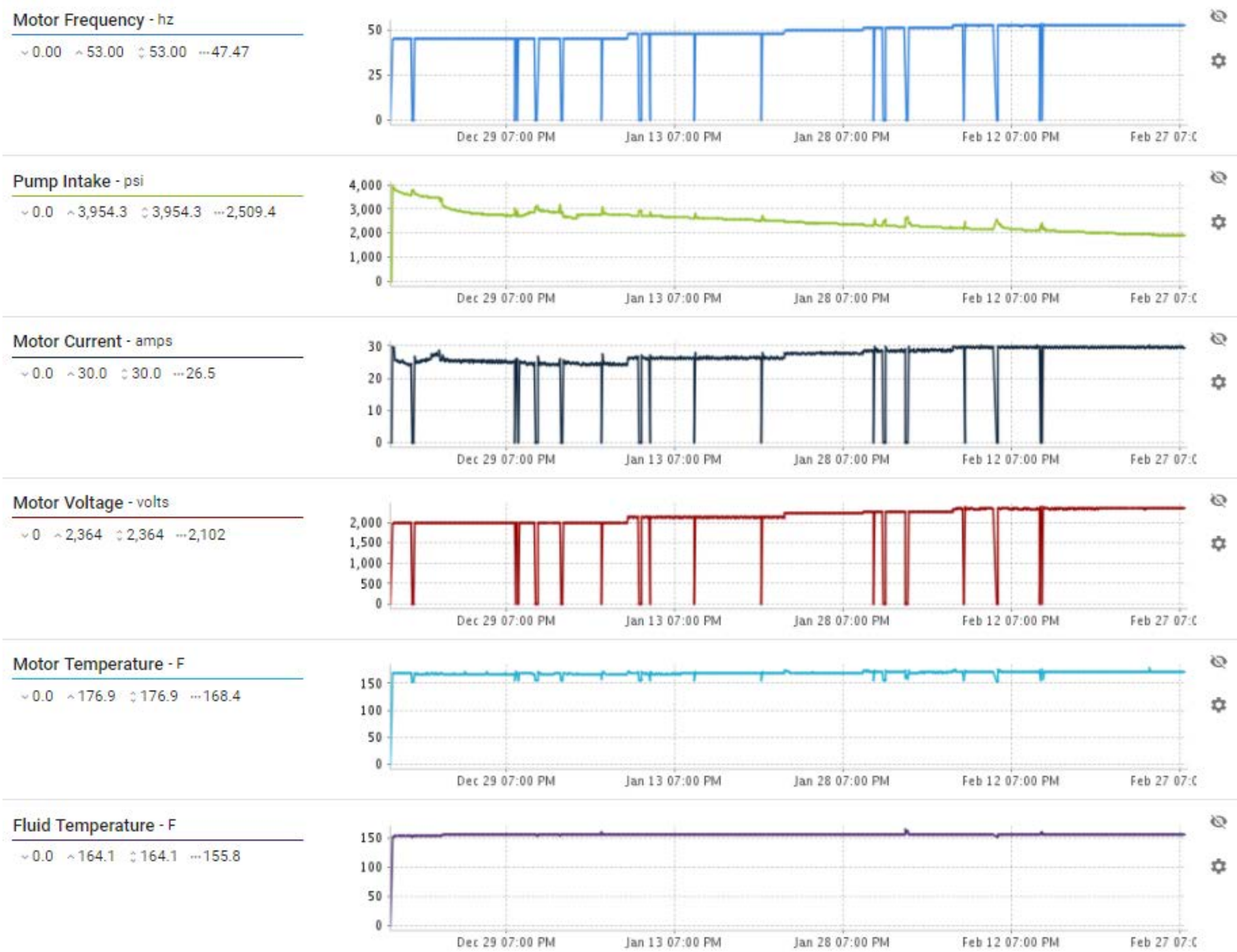

Figure 15. Sensor parameters AFTER Guardian Shield Installation – SOA SE 0041WB