Avoiding Environmental and Financial Impact of Stuffing Box Spills While Increasing Revenue on Rod Pumped Wells

Victoria Pons, Ph. D., Pons Energy Analytics

Rob Harrison, Well Site Guard

Elaine Lang, Well Site Guard

Abstract

Prevention technology can help companies minimize their environmental footprint at the source. Operating companies today recognize the benefits of providing a safer work environment and minimizing their environmental impact while minimizing operational expenses.

With an increase in hydrocarbon extraction across the United States over the past few decades, comes more concern over the preservation of the environment. Unfortunately, with oil exploration and extraction practices comes inherent risk of leakage or spills. These spills can range in magnitude from a few gallons or multiple barrels spills, as the result of stuffing box seal failure, deteriorating infrastructure, and inadequate handling practices.

Produced water is the largest waste stream generated by the oil and gas industry. Produced water generally consists of naturally occurring brine present in the reservoir and water injected nearby to push the hydrocarbon deposit into production wells. Also, for shale and tight oil, fracturing fluid and a solid material, called proppant, are injected into the reservoir under very high pressure in order to create fractures aimed at increasing the porosity and permeability of the rock formation. In summary, these contaminants include dissolved salt, petroleum, and other organic compounds, suspended solids, trace element, bacteria, naturally occurring radioactive materials (NORM) and anything injected into the well.

Costs related to a small stuffing box leak or a critical seal failure, such as stuffing box seal repair, very often requires an unplanned pump shut down for extended period, site, and equipment cleaning, using third party companies, vacuum trucks, steamer/pressure truck, specialty waste hauling services, as well as reclamation of surrounding ground surface, contaminated soil removal and disposal at an authorized site plus the potential regulatory fines.

In this paper, Well Site Guard's solution to stuffing box leak prevention is presented as well as its significant financial impact on the customer's operational expenses. Environmental justification for this small investment in capital expense is weighed against the staggering cost of spills and leaks. Finally, cost savings results are discussed followed by case study results and operator feedback.

Introduction

According to [1, 15], when analyzing a study of over 31,000 horizontal wells, about 5 percent of the wells reported an oil spill. With a median reported spill ranging from 120 gallons (454 L) in Pennsylvania to a staggering 1302 gallons (4928 L) in New Mexico, most spills involved produced water and, in some cases, flowback of hydraulic fracturing fluid.

Anything injected into the well ends up in the produced water and part of the spill. As estimated in 2007, 57.4 million barrels of water were produced daily, this number has seen a drastic rise with the increase in hydrocarbon production across the United States, cf. [2].

When using sucker rod pumps, an average production of 12-20 pints (6-40 liters) of liquid is produced per stroke. Produced liquid is usually an emulsion of crude oil and water. Pumping speeds expressed in stroke per minutes average 7 strokes per minute or 10,800 stroke per day. A stuffing box has a replaceable packing seal designed to withstand repetitive rod travel and prevent major leakage. However, a small amount of produced fluid seeps out at every stroke of the pumping unit, called routine seepage, which can accumulate into a bigger leak. Packing wears and must be replaced every 3-12 months depending on the oil emulsion. The potential for leaks greatly increases as the packing seal wears. Unlike similar products in the industry, Well Site Guard (WSG) is easy to remove and install making packing seal maintenance practical and fast and presents a clear advantage with its quick and easy re-install, unlike other products, which either need to be discarded and replaced after removal or involve a more extensive and tedious re-install process.

In North American wells, the ratio of produced fluid to oil is 10-12 barrels of water to each barrel of oil. Visible well leakage can mean that for every ounce of oil on the surface, as much as 12 ounces (0.35 L) of water and salts have already seeped into the ground. Contaminates from leaked produced water are left behind on equipment and soil surfaces to be washed into the ground by the next rain or snowfall.

Water produced along with oil and gas is often naturally salty and may contain oil residues, chemical from hydraulic fracturing and drilling fluids, and natural contaminants from the rocks themselves, see [5].

Produced water is the largest waste stream generated by the oil and gas industry, cf. [16], and generally consists of naturally occurring brine present in the reservoir and water injected nearby to push the hydrocarbon deposit into production wells. Also, for shale and tight oil, fracturing fluid and a solid material, called proppant, are injected into the reservoir under very high pressure in order to create fractures aimed at increasing the porosity and permeability of the rock formation. In summary, these contaminants include dissolved salt, petroleum, and other organic compounds, suspended solids, trace element, bacteria, naturally occurring radioactive materials (NORM) and anything injected into the well, cf. [2]. The rapid increase in hydrocarbon production across the United States, particularly for shale gas, tight gas, tight oil, and coalbed methane, has led to a corresponding increase in produced water volumes and therefore ensuing leaks.

It is a vital necessity to use safer equipment monitoring aimed at reducing the number of spills due to technical and mechanical failure to minimize the repercussions of pollution on different environmental fates and repercussions on air, soil and groundwater, cf. [17].

Whether the impact of the Well Site Guard (WSG) is to keep control over minor spills, improve efficiency of field personnel who spend countless hours a day cleaning up minor leaks from leaking stuffing boxes or allowing for better scheduling and flexibility for packing seal maintenance, this small investment in CAPEX becomes a significant return in OPEX.

Not only does WSG prevent foreign contaminants from entering and damaging the stuffing box, therefore reducing, and delaying stuffing box failures, but WSG dramatically frees up expensive personnel time, who routinely spend a high percentage of their daily work cleaning up minor leaks from the stuffing box and surrounding area.

WSG also offers flexibility for the operator to schedule stuffing box maintenance at their convenience, by capturing leaks and preventing larger spills and therefore the heavy fines that may incur.

Aside from the fact that protecting the environment should be a primary concern, WSG also returns on investment by minimizing downtime from stuffing box maintenance operations, avoiding clean up and remediation costs, the liberty to allocate personnel's time to optimization instead of clean up and lowering stuffing box leaks and related maintenance costs. Finally, in an era when reducing the carbon footprint of an installation is essential, proactive operators who prioritize safety for the environment and longevity of their installation are more profitable than reactive operators, who wait for a spill to happen and endure the corresponding financial repercussions.

Moreover, as Benjamin Franklin once said: "Beware of little expenses. A small leak will sink a great ship".

In this paper, the Well Site Guard technology is presented in the first section. The financial and environment impacts are presented in Section 2 and 3 respectively. Finally, results are discussed in Section 4, followed by conclusions.

I) What is Well Site Guard

a. Components and features

The Well Site Guard is a proactive state of the art stuffing box spill prevention system, which collects spills and notifies the operator for action or shuts down the well when the spilled fluids reach a certain amount. The Well Site Guard is composed of a power coated aluminum basin, a permanently attached urethane seal, and only stainless-steel fasteners and valve components as well as a UV resistant polycarbonate clear top. The Well Site Guard unit is shown in Figures 1 and 2.

i. Power coated aluminum basin

Aluminum was chosen for WSG's basin. Aluminum's properties of light weight and strength bring fundamental advantages when cast into parts.

Casting is a versatile way of forming aluminum into a wide array of products. Such items as power transmissions and car engines and the cap atop the Washington Monument were all produced through the aluminum casting process.

ii. Permanently attached urethane seal

Polyurethane is a polymer compound with many versatile uses. It is employed in the marine, fuel, and manufacturing industries, among countless others. One of the main factors in polyurethane's versatility is that it exists as a liquid before molding and casting. This allows the material to be formed into a wide variety of shapes, from hourglasses for pipe rollers to caps for offshore oil rig wellheads.

With its light weight, versatility and resistance to corrosion, polyurethane is well suited to a variety of oil & gas industrial applications. Well Site Guard's molding and casting method allows the urethane seal to be custom designed to provide solutions for even the most specialized jobs.

These attributes permit the removal and replacement of a Well Site Guard leak containment unit as many times as necessary for wellhead service work, with no deterioration in its ability to maintain a complete stuffing box attachment seal, through the fact that it is permanently bonded.

Similar products in the industry contain narrower seals that do not provide complete seal from the lack of compression fit.

iii. UV resistant polycarbonate clear tops

Polycarbonate plastic (PC) sheets offer optimal weather resistance—providing high-transparency without compromising on durability and strength. PC is durable, heat resistant and malleable, making it ideal for our manufacturing purposes, protection, security, and weather resistance. Well Site Guard uses UV resistant materials to prevent sun yellowing, as seen in Figure 1. Other applicational examples showcasing the strength of polycarbonate include impact and bullet resistant windows, hockey rink protective panels, plastic lenses in eyewear and safety glasses, as well as personal protective gear. WSG's PC tops do not absorb oil or production waste stuffing box leakage spray, they can be easily cleaned with commonly available citrus products.

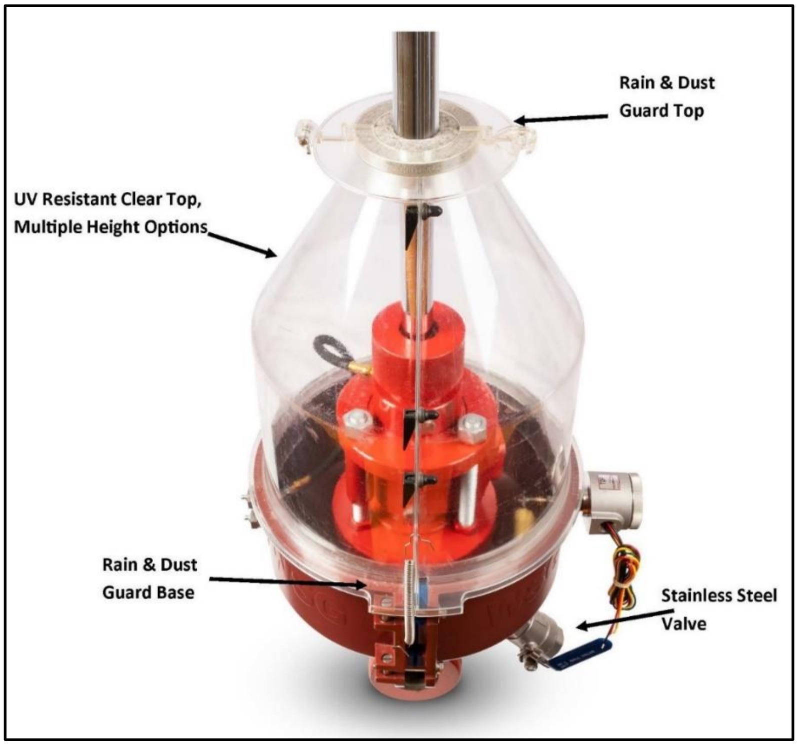

Figure 1: Well Site Guard unit with rain guard

iv. Stainless steel vs. ductile iron or cast iron

WSG uses only stainless-steel fittings, fasteners, and valves.

Why does it matter which one we use? Is spending the extra money on 316 stainless-steel going to make a difference? In a word, yes! H_2S and other produced waste wreaks havoc on oil and gas infrastructure. These corrosive elements are found in the highly acidic hydrocarbons ubiquitous to crude oil and refinery operations. Carbon steel valves and fittings become embrittled, suffer oxidation and experience the loss of electrons due to contact with H_2S. Stainless steel is specified for high temperature and corrosive applications with potential H_2S environments. One cannot ignore the laws of chemistry hence the potential presence of H_2S in hydrocarbon production must be factored into application specifications.

v. Ultrasonic switch

Murphy float level switch vs. ultrasonic switch. WSG's ultrasonic switch does more than just measure the level of the fluid collected in the basin, shut off the pumping unit and notify the operator; it also has the ability to run extra signal lines, which can be linked directly to the operator office. This allows the operator to have more options when it comes to monitoring, enabling better optimization. This lowers the risk profile by one level which means a decrease in the cadence of everyday inspections, and de-risks the unit while staying compliant with regulation.

Other features

One of the key features of WSG is the rain guard which prevents rain, debris, dust, and other contaminants from entering the stuffing box. This slows down the wear and helps prevent stuffing box seal failures.

WSG also allows for external lubrication lines and can accommodate up to two integrated grease lines to shorten maintenance work at the stuffing box.

Well Site Guard units come fully assembled, unlike similar product which can require complex and time-consuming assembly. The height of the top cone can be adjusted in the design per operator's needs. Each unit is engineered to design, which allows Well Site Guard to accommodate non-flow Tee well applications as well.

Longevity – Well Site guard is built to last indefinitely and unlike similar products can be taken off and re-installed on a well without compromising the sealing effectiveness of the unit. All components are built to last to provide operators with the best return on investment possible.

Another advantage of the Well Site guard is its ease of install, see [13]. Most other similar products require a non-negligible amount of time for removal and re-install, and most often requires work by several field personnel. With Well Site Guard complete removal and re-install takes no more than 20 minutes and can be safely done by one field technician alone. This simplifies the use of this technology with the numerous workovers necessary during the course of a well's life cycle.

The shape and position of the valve is designed to be the optimum shape with the least amount of interference with standard wells but remains specific for each unit. Last but not least, each WSG unit comes with a high-level float switch which detects when the oil leak accumulates to a certain amount and either activates the kill switch to shut down the well or notifies the operator so action can be taken on the well. This captures leaking of produced fluids and prevents bigger spills occurring before an operator can act.

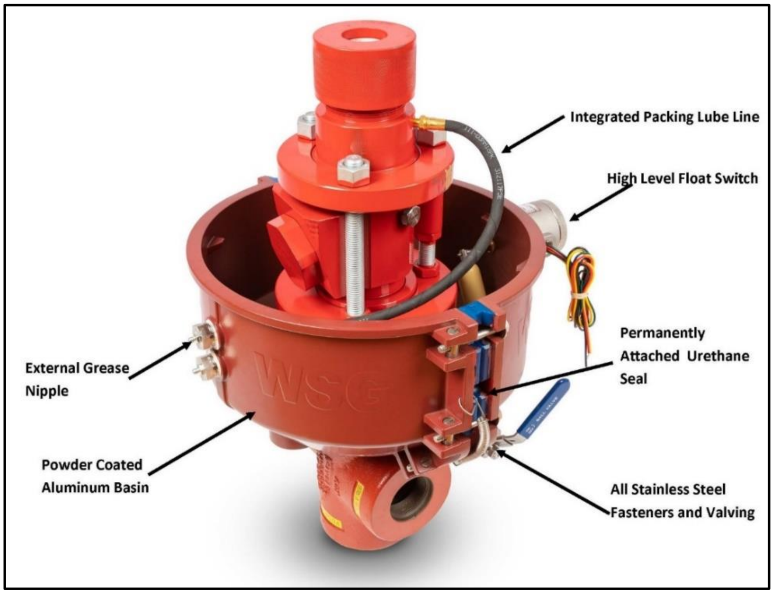

Figure 2: Well Site Guard components

b. Proactive vs. Reactive

The use of stuffing box containment also provides the operator a proactive risk reduction opportunity to avoid Government environmental fines. Combined with the incalculable benefit of improving and protecting the public corporate image, while meeting their obligation to shareholders of a respectful return on their investment. Trying to estimate the cost of a spill can be a difficult and tedious process. Simply waiting and hoping a spill will not happen can be a very costly attitude for operators.

The EPA Basic Oil Spill Cost Estimation Model (BOSCEM) was developed to provide the US Environmental Protection Agency (EPA) Oil Program with a methodology for estimating oil spill costs, including response costs and environmental and socioeconomic damages, for actual or hypothetical spills.

The model specifies 8 separate factors for cost consideration:

- Per-Gallon oil spill response costs
- Socioeconomic base per-gallon costs
- Environmental base per-gallon costs
- Response Cost Modifiers for Location
- Socioeconomic & cultural value rankings
- Response method and effectiveness adjustment factors
- Freshwater vulnerability categories
- Habitat and wildlife sensitivity categories.

In contrast, a pro-active installation risk avoidance approach includes avoiding daily cleanup costs, avoiding environmental damage, avoiding socioeconomic and corporate image damage by decreasing the size and frequency of spills and avoiding government fines. A pro-active approach means that a small upfront cost in CAPEX means significant savings in OPEX by reducing the environmental operational budget per well and per field and reduce the overall cost of lifting per barrel.

II) Financial Impact

a. Cost of a spill

The EPA Basic Oil Spill Cost Estimation Model (BOSCEM) is a methodology used by the US environmental Protection Agency (EPA) for estimating oil spill costs, including response costs and environmental and socioeconomic damages, see [6, 7].

The first step in oilfield spills is typically to capture spilled fluid using absorbent material, spill containment berms. Then steam clean equipment, excavate, and remove any contaminated gravel, soil and plants either by hand or with 3rd party, vacuum tanks. If this is done quickly, spilled material can be prevented from spreading further into soil and entering ground or surface water, see [4].

Delays in responding to a leak can be very costly, which is why WSG's advanced notification system makes a big difference in return on investment for the operator.

It was reported by operators than a majority of the time spent by their field engineers each day was to clean up minor spills or leakages around stuffing box in an effort to prevent a bigger leak or spreading of the unavoidable leak caused by routine seepage. Using Well Site Guard significantly reduces if not eradicate time spent on labor to clean up basic stuffing box spills as well as equipment and resources used for clean ups.

Cost multiplier	Product	Response	Cost per gallon
Per-Gallon Oil Spill Response Costs Applied in EPA BOSCEM1	Crude Oil	Mechanical	$199
Socioeconomic Base Per-Gallon Costs	Crude Oil	Mechanical	$50
Environmental Base Per-Gallon Costs For Use in Basic Oils Spill Cost Estimation	Crude Oil	Mechanical	$90
EPA BOSCEM Response Cost Modifiers for Location Medium Type Categories1	Crude Oil	Wetland modifier	$54
EPA BOSCEM Socioeconomic & Cultural Value Rankings	Crude Oil	Moderate	$24
Response Method and Effectiveness Adjustment Factors	Crude Oil	Mechanical	$34
EPA BOSCEM Freshwater Vulnerability Categories	Crude Oil	Wildlife	$58
EPA BOSCEM Habitat and Wildlife Sensitivity Categories1	Crude Oil	Agricultural	$75
Spill Amount in Gallons	**Total cost**		
1 gallon	$583		
5 gallons	$2,915		
10 gallons	$5,830		
25 gallons	$14,575		
50 gallons	$29,150		
100 gallons	$58,300		

Table 1: Typical clean-up cost rates – Etkins FSS 2004

Table 1 displays the typical clean-up cost per hour. As can be seen by Table 1, one 5-gallon spill avoidance completely recovers WSG's unit cost and any installation expense. WSG's basin contains 2.11 gallons (8L) of fluid, meaning that before the basin has filled up twice, the Well Site guard unit has already paid for itself and its installation expenses.

Routine seepage is the amount of fluids seeping out of the stuffing box during its normal day to day operation. Routine seepage results in field crews having to spend daily time cleaning up the equipment and around the well head. Typically, routine seepage can fill up Well Site Guard's basin in a period of several days to several months, depending on the well.

Factors that greatly affect the cost of a spill include the percentage of crude oil and toxicity of produced water, the impact on wetlands, agricultural land, and surrounding area. Remote locations and the ability to use manual techniques or requirement of 3rd party equipment. The economy of scale can also be applied here, where typically larger spills have a lower unit cleanup cost, that can range from $553 per barrel to $7,372 per barrel. Spills impacting navigable waters was found to add an average of 187% to total spill costs, see [3]. Other factors that affect spill cost are spill volume, oil type, proximity to water, location remoteness, and cleanup methods. Saltwater content in production fluid creates additional contamination issues. Crude oil varies drastically with one end of the spectrum being bitumen to light oil and distillates.

Location affects the cost of a spill since the more remote the location the more difficult and expensive the clean-up, as there is tangible difficulty in getting the equipment to the well. Also, chemicals must be disposed of in a specialist landfill, which can make trucking cost skyrocket based on the location of the spill. One of the most common methods for spill cleanup is the "dig and dump" method which involves removing all the contaminated soil and trucking them to the nearest regulated landfills.

Factors that greatly increase the cost of a spill are:

1) Sandy soil or clay-based soil
2) Spills in waterways: fast- moving water is the fastest way to escalate spill costs
3) Spills in muskegs, which are giant, slow moving rivers or swamp land require costly reclamation procedures
4) Wet conditions offer a particular challenge since traditional spill products are not as effective in a wet environment
5) Old fashioned sorbents operate to less than one third of their capacity in a wet weather
6) Standard sorbents also are very bulky and require significant storage space, which can limit the number of products workers can carry to location.

In wet conditions, old fashioned sorbents operate at less than one third of their capacity. Also, standard sorbents being bulky and requiring significant storage space force clean up teams to carry only a fraction of the sorbents required for cleanup, see [4].

Regulatory analysis, cost-benefit analysis, resource planning, and impact analysis related to oil spills involves assigning a value for the damages caused by an oil spill.

b. Return on investment with Well Site Guard

As mentioned above, WSG has more than one very important advantage, which are described in more detail in this section.

(1) Well Site Guard delays and reduces stuffing box leak failures by preventing foreign contaminants from entering the stuffing box and accelerating seal failure with its rain guard feature. The rain guard as described above restricts water, sand, dirt, leaves, and other items getting into the basin. The felt wiper seals keep the polished rod clean, stopping contaminants being carried to the stuffing box seal, extending its life, and reducing maintenance expense.

(2) Despite our continuing advances the mechanical function of rod lift units will always be susceptible to wear and leakage because of low oil cut friction, high water volumes and pitted polished rods, as well as misalignment of the pumping unit with the wellhead.

With normal packing wear mild leakage begins, this can increase to points where ground contamination occurs. Currently your operators are tasked daily with well cleanup, replacement of wiper rags and absorbent wraps.

With a bad enough leak then ground contamination becomes an increasing risk, it takes an operator one to two hours to clean up the mess and longer to replace the stuffing box packing. This usually involves cleaning the wellhead, disassembling the stuffing box, removing old packing, reinstalling new packing, removing the spilled oil and contaminated ground. Then replacing the affected area with clean gravel.

Operators report that a vast majority of their field personnel's time is spent cleaning leaking stuffing box, equipment, and surrounding grounds on a daily basis. Several field technicians reported spending over 60% of their daily routine on cleaning duties instead of spending their time optimizing production on their installation. WSG removes the need for clean-up and frees up that time for the field technicians. This alone is a significant cost saving.

(3) Most packing fails because of friction heat buildup from contact with the metal polished rod during operation. Other failure occurs as a result of pumping unit misalignment, pitted polished rods, pumping off oil well or a well that produces salt water and brine. All these factors can wear the packing and create oil leaks and spills at the wellhead.

Using WSG also allows the operator to be more flexible with maintenance schedule. Imagine the scenario where a stuffing box seal is wearing out and needs to be replaced. As that process takes place, the stuffing box releases more and more fluids which if left unchecked can turn into a significant dollar amount for clean-up. With WSG, the operator is notified when the fluid collected in the basin reached a certain level and can better schedule the maintenance needed on the well without having to rush there to avoid a spill.

(4) Over the past 100 years environmental concerns have continued to rise, the need to keep oil from leaking into groundwater, streams and waterways has become a pressing concern.

Oilfield waste are any unwanted mixture of substances that are generated at any stage of a well's lifecycle, from construction to reclamation. It is of the utmost importance to protect the ground and surface waters from contamination.

From an environmental point of view, preventing and taking proactive actions to reduce spills is the right thing to do. But even more relevant for operators is the avoidance of a potential costly spill. A stuffing box leak left uncheck can have disastrous consequences to surrounding lands and environment, which in turn can mean heavy fines. WSG notifies the operator when the spill level is reached but also has the ability to stop the well to ensure the produced fluids do not overflow the basin therefore preventing a spill.

(5) Adopting WSG as part of day-to-day use and activities, allows operators to show their customers a proactive behavior as opposed to a detrimental reactive approach which can damage the operator's reputation and be very costly in damage minimization costs.

WSG prioritizes environmental stewardship by minimizing the risk and impact to plants and wildlife while operating pumping units and extracting crudes. WSG also promotes an example of corporate social responsibility by avoiding damage to corporate name and brand due to an uncontrolled leak and promotes a “pro-active” attitude to environmental exposure. Well Site Guard’s risk mitigation provides a clean and safe working environment for field engineers by reducing AER fine exposure for major stuffing box seal failure. A source of confidence for investors and corporate leadership by promoting cost reduction savings through innovation and confidence in regulatory compliance, “Operators with a purpose”.

(6) Last but most importantly is the financial aspect of using WSG. WSG directly and indirectly saves the operator money by minimizing downtime either from less failed stuffing box seals to less time spent removing and installing the stuffing box leak prevention system but greatly minimizes clean-up costs and remediation costs due to stuffing box seal wear. Finally, as mentioned above, another financial advantage is the proper allocation of the field personnel’s time and clean-up costs savings as well as significant savings in maintenance costs, frequency and reduced failure rate and downtime.

Figure 3: Well Site guard unit on the field

An average oil well is checked once every 24 hours, however remote locations may only be checked 48 to 72 hours. Even a small leak can quickly lead to environmental damage and a costly clean up. Depending on the leak rate, a couple of hours can be the difference between a small easy to clean up leak and a significant leak requiring remediation. Increased volumes of produced water are destructive to stuffing box seals.

All new units come complete with one or two external grease line kits. The rain and dirt guard helps reduce stuffing box seal wear from air contaminants. These improvements are also available as retrofit kits for existing units. Figure 3 shows a picture of the Well Site Guard unit on the field.

III) Environmental

The exploitation of natural resources has led to changes in the environment, often irreversibly. Hence the need to develop, in parallel to the new technologies, research aimed at preventing potential ecological disasters and remedying contamination cases.

Why is containment necessary on production wells? Reclamation planning is required to achieve viable post-production land use, minimize environmental impact to be consistent with local land use policies/comprehensive plans, and meet all regulatory compliance requirements. Planning must take into consideration all aspects of the operations including production and support areas. Reclamation is both an art and a science and should be given consideration in the earliest stages of planning and permitting to assure economic viability and environmental success of oil and gas operation.

When a spill occurs, operators face cascading clean up and remediation costs. Design and engineered from operator’s feedback, WSG aims to reduce if not eradicate leaks from stuffing box daily use and stuffing box packing failure.

The goal of remediation is to remove and make harmless, substances contaminating the soil or groundwater, cf. [14]. Several techniques for non-biological remediation involve soil washing, solvent extraction, soil vapor extraction, air sparging, dual phase extraction, solidification/stabilization, thermal desorption, and incineration. Each technique is either carried on site or the contaminated material must be carried off site for treatment. Each technique offers different levels of effectiveness and critical issues. For example, when using soil washing, which is done onsite, soil decontamination is accomplished by washing with water and possible addition of other substances such as chelating agents, surfactants, acids, or base. This method however is not optimal for treating chemically absorbed metals since it involves physical separation. Biological remediation techniques include bioventing, natural attenuation, landfarming and biopiles.

In wet conditions, traditional methods for spill cleanup can be less effective and require more spending.

The environmental impact of a spill depends strongly on the size, location, type of fluid and the spread of the spill including whether or not it contaminates ground or surface water, which allows it to spread further and makes clean-up operations more difficult, see [8, 10, 11, 12].

Most wells are set up to run 24 hours a day, making it so that unless an alarm on the well goes off, the operators does not service the well daily. One drop of oil every 10 seconds is next to impossible to observe. However, one drop every ten seconds equals 18.25 ounces every 24 hours or 415 pints (196 liters). With about 15% of wells leaking within their first year, for an operator producing 50,000 wells per year, this equals to 3.1 million pints (1.46 million L) of oil each year, which equals 12,550 barrels per year.

Operators catch most of these daily leaks and spend a large part of their day to ensure the well site is cleaned and major problems and fines are avoided. This expense of operator productivity and maintenance cost can be avoided with the Well Site Guard.

IV) Results

a. Customer driven approach

Well Site Guard is a customer driven product aimed at protecting customer's wells from leaks and guaranteeing return in investment while prioritizing an environmental focus.

Customers have extended the installation of Well Site Guard to all their new wells to provide protection against packing leaks with the main economical factor being the cleanup costs. In addition, many operators have seen fit to retrofit older wells with Well Site Guard, when those are in environmentally sensitive areas or show signs of repeat packing failures.

Many operators' main objective is to minimize and reduce spills, with a "Driving to Zero" approach to leaks and cleanup costs. Customers have reported a 20% decrease in the wellhead/packing leaks since installing well head protection equipment on their wells.

According to all operators, the initial cost of installing Well Site Guard has more than paid for itself in terms of cleanup costs and avoided spills.

b. Cost savings of using Well Site Guard

According to a study by Patterson [15], about 15 percent of wells surveyed had a spill with about 75 percent of those spills occurring in the well's first three years. In annual number of spills per thousand well-years, spills due to stuffing box leaks ranged from 0.2 in Colorado to 8.2 in North Dakota, averaging at 2.6 with is greater than the number of spills from blow outs and all other wellhead spills or pump spills.

Working with North American producers, the total expense of cleanup and remediation costs relating to stuffing box leaks when amortized over the entire field, averages out to $2500 to $4500 per well per year.

Figure 4 shows a forecast the expenses and potential savings based on the number of wells over a period of 3 years. As can be seen in Figure 4, after an initial CAPEX cost of $1800 per well the cost savings on cleanup and remediation costs is reduced by up to 80% for an example of 300 wells, meaning $1,620,000 savings in operation expenses costs.

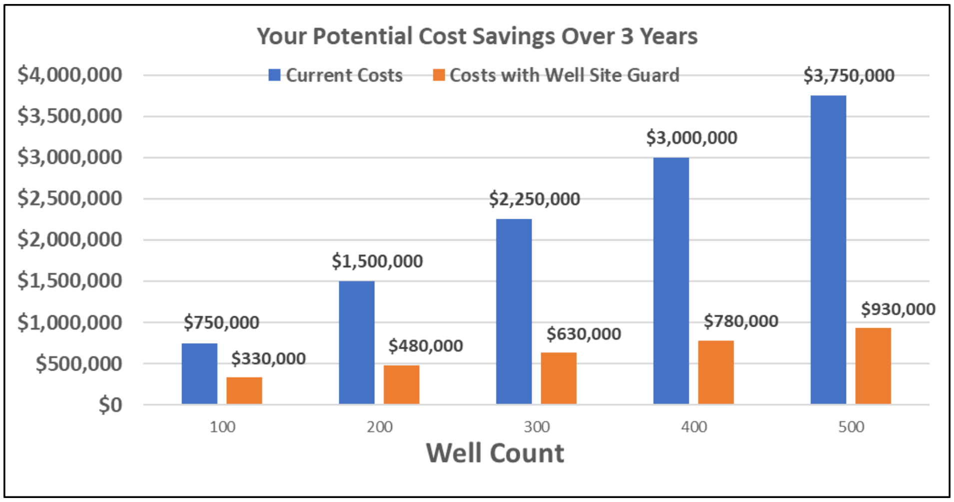

Figure 4: Potential Cost Savings with Well Site Guard over 3 years

Note: Costs with Well Site Guard include first year Capex expense of initial purchase

Following are the current standard costs as reflected by current daily field operating procedures. Cost is estimated by current users, for total field expense when averaged over total number of wells is $2,500 to $4,000 per well and includes the following:

- Operator labor per day, multiple estimates ranging for 35% to 80% of day is reacting to minor leakage and issues with oil seepage. Requiring equipment cleaning and replacement of absorbent wraps and rags
- A reactive necessity for actual stuffing box leakage, requires shut down of well production until replacement seals can be sourced and stuffing box repaired
- Labor for site remediation, 3rd party services, steam truck, vacuum trucks, and hazardous material transportation
- Disposal fees for contaminated soil and transportation cost to nearest registered facility
- Procurement of clean soil, gravel, and labor for replacement of contaminated area
- Annual cost for disposable absorbents, absorbent wipes, onsite hazardous waste containment rental and disposal service
- Well site insurance liability expense and funding of deductible amounts in case of a spillage

Not included in the above is regulatory fines if spill exceeds reportable requirement, fines for excess spillage outside of lease site on to agricultural, wetlands or public domain.

The cost with Well Site Guard includes:

- Basic Well Site Guard unit is $1,800 per well, which does require electrical hook up
- Installation labor one operator under 30:00 minutes per unit

The difference with or without WSG can be summarized as follows:

- One-year current cost is $2,500 per well for 100 wells = $250,000
- One time Capex investment in first year of $1,800 for 100 wells = $180,000
- First year estimated saving @ 80% of $2,500 per well for 100 wells = $70,000
- Savings per year for year $200,000, 2nd & 3rd, years savings total = $440,000

Figure 5 shows a field where Well Site Guard units were adopted field wide as a solution to stuffing box leak issues. Well Site Guard has the best impact when part of an entire field solution as can be seen above. It's impossible to know which 5% of the wells on a field will leak. With Well Site Guard, this unknown can be mitigated.

Figure 5: Well Site Guard units installed on the field.

c. Minor spill cost example related to stuffing box seal failure

As per [9], a failed stuffing box seal caused 84 gallons (317 L) of oil spill, which was the second on the Aliso Canyon field in that year. In this spill, two barrels or 84 gallons of oil mixed with produced water and gas spilled or sprayed the area round the well head. The operator was able to stop the leak within a few hours after the notice was given. This event was recorded on social media and breaking news organization damaging the company's reputation and starting an investigation by the chief deputy director of the California Department of Conservation. Even though the amount spent by the operator to clean or remediate the spill was not shared, this could all have been avoiding with Well Site guard. WSG collects produced fluids that leak out of the stuffing box until those reach a certain level. Once the critical level is reached either the pumping unit is shut off automatically or the operator is immediately notified for action. Leaks over 3 barrels, represent a fine from regulatory agency if the oil gets off site, with a minimum fine is $75,000. In the above case, best case scenario, investing in WSG would have avoided this leak and saved the operator over $45,000.

d. Case Study results on current customers

Producers quicky noticed a significant decrease in their monthly operating expenses within a few months of covering their field with Well Site Guard units, however, could not state where these reductions were coming from. With help from their cost accountants, it was identified that multiple direct costs that are related to a small stuffing box leak or a critical seal failure. These costs include the stuffing box seal repair, very often requiring an unplanned pump shut down for extended period, site and equipment cleaning, using third party companies, vacuum trucks, steamer/pressure truck, specialty waste hauling services, and reclamation of surrounding ground surface, contaminated soil removal and disposal at an authorized site not to mention the potential regulatory fines. Once properly accounted

d. Case Study results on current customers

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Conclusions

Driven by operator feedback, WSG maximizes return on investment by effectively preventing spills and expensive clean-up operation, which can be damaging to the operator's reputation. WSG also reduces time spent by field personnel cleaning up day to day operations while allowing for more flexibility and reduction of stuffing box seal maintenance.

Installing stuffing box leak prevention technology is a proactive way to reducing OPEX spending while fulfilling an operator's commitment to environment stewardship.

The team at Well Site Guard spent years researching how to make the ultimate product for the oil and gas industry, which has made WSG the industry standard in stuffing box leak prevention technology.

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