AN INNOVATIVE APPROACH TO FRACTURING WITH LONG TERM RESULTS IN PRODUCTION

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In the oilfield industry drilling, completion, and production are all the responsibility of different departments. Each phase in the life of an oil or gas well is being scrutinized and restructured as an independent event. Oil and gas wells are typically drilled, completed, and put on production with an emphasis on completing each task in a manner to minimize costs. If a problem is created in either the drilling or completion operation, the production department will be forced to deal with results of the problem which can last for the well's lifetime. This paper deals with a novel approach that treats the well for production issues during the completion/stimulation stage of the well.

There will never be a better opportunity in the well's lifetime to treat production issues before they occur. This is true for both wells with a single set of perforations and multi-perforated completions. However the production problems are magnified in wells producing from multiple sets of perforations. This process has been applied to the Wolfberry which is typically a multi-stage completion, but is applicable to essentially all wells. The formation during this treatment is in as near a virgin state as is possible. Never again will the opportunity exist for treating the well in this state.

Many of the problems resulting from the frac are directly caused by the supply water. Three basic problems originating from the supply water source and frac equipment/procedures being used occur during the frac. These problems can seriously affect the life expectancy of the well.

1. The formation of scale (seed scale) back in the formation and fractures can cause restrictions in the fluid entry to the well. Water incompatibility from formation fluids mixing with different formation fluids and/or formation fluids mixing with completion fluids can result in scale precipitation. An increase in pressure from the frac itself can cause scale precipitation. Temperature changes caused by pumping cold water in the completion fluids into the formation can result in precipitation of barium and strontium scales as the formation is cooled. These scale precipitations are generally rapid and restrict the number of fractures with inflow to the well bore.

2. The presence of iron sulfide in the formation can be caused by the presence of H_2S and bacteria in the frac fluids being introduced into the formation. Iron sulfide is responsible for more plugging and corrosion related failures than any other solid in the oilfield industry today. Iron sulfide is minimized by limiting either hydrogen sulfide and/or iron present in the well. Typical treatments for control of iron sulfide include but are not restricted to biocides, H_2S scavengers, iron chelators, iron sulfide dispersants, and low pH surfactants. Again, as with scale precipitation iron sulfide can restrict the inflow of fluids to the well bore by plugging of the fractures.

3. During drilling or completion operations, waters from various sources are utilized. Water for completion (especially fracturing) is often taken from open pits, lakes, streams, large storage tanks, and frac tanks. Due to environmental concerns, treatment of these waters for bacteria is often limited. Bacteria in these waters may be introduced into the formation through the fractures. The bacteria found in these waters often include species of sulfate reducing bacteria as well as acid producing bacteria. The by-product of the "sulfate reducers" is hydrogen sulfide (H2S) which leads to the souring of oil and gas wells. This souring will lead to iron sulfide precipitation, increased corrosion rates, and increased toxicity. The presence of acid producing bacteria will lead to increased corrosion rates and precipitation of various iron compounds. Completion procedures carry the bacteria far back into the formation by the way of the fractures, thereby making control of bacteria after the well is completed extremely difficult and costly.

CASE HISTORY

A chemical company, with the cooperation of their customer, monitored frac procedures and results in a selected, established field in Upton county. New wells were being put on line and rapid production declines and numerous failures were occurring. The wells are completed by fracturing the Wolfberry with 8 stages. Production figures are outlined in the charts below, well #1 and well #2 indicate wells fractured with the new method, well #3 and well #4 were fractured with the standard frac method and products. All 4 wells were fractured by the same frac company and equipment. The wells were monitored for 12 months.

Tests were performed on the water at the well head of wells #3 and #4 to determine if the scale inhibitor (.5 gallon per 1000 bbls.) from the frac was still present in the produced fluids. The results were positive for a phosphonate product, yet the decline in fluid entry continued. The lease had 13 producing wells which had been fractured using their standard fracturing procedure. This procedure included .5 g/m scale inhibitor and .4 g/m biocide and nothing for iron or H_2S control. These wells had a 30% failure rate within the first 11 months. Water samples from the well heads were blackish in color and were high in sulfides and positive for both Sulfate Reducing and Acid Producing bacteria. During work over of the wells, calcium carbonate scale and iron sulfide were found in the down hole equipment. Due to casing pressures and high fluid production, treatments for scale and iron could not be applied during the first several months of the well's production life. During these months severe damage to the casing, tubing, and rods were occurring as well as precipitation of scale and iron sulfide. It was decided the wells needed cleaning up and scale inhibitor squeezes. The need for the scale inhibitor squeeze was rejected due to the cost of properly squeezing the multi-stage well which included isolation of each stage.

It was decided that the most cost effective solution was to design a program to control iron sulfide, bacteria and scale for these wells in the completion procedure. The application would be applied in all 8 stages of the frac. To initiate our procedure we had to develop H_2S scavengers, Biocides and squeeze type scale inhibitors that would be compatible with the frac fluids and comply with the frac company's approval. The key to the success of the program would rely on the application of the products into the frac.

1. Hydrogen Sulfide Scavenger and Biocide- A hydrogen sulfide scavenger was developed to be applied into the end of the 1,500 gallons of NEFE Acid pad, 30 gallons of the hydrogen sulfide scavenger product along with 5 gallons of biocide were added. The purpose of the Scavenger was to control the presence of hydrogen sulfide in the formation. Scavenging the H_2S would reduce the formation of iron sulfide, blackish water, and H_2S related equipment failures. The purpose of the biocide was for control of bacteria that may be in the formation or in the fluids being pumped into the formation. The primary goal was to keep the formation and fractures free of iron sulfide precipitation allowing for more migration of oil/water and gas to the well bore.

2. Scale Inhibitor- The scale inhibitor is a combination of several scale inhibition mechanisms providing a wide range of protection. It was designed to precipitate in the presence of calcium allowing for residual product to find its way into small cracks and fractures providing long term scale inhibition. Compatibility of the product with the frac fluids was a requirement which makes this product very unique. The product is put into the pre-pad at the rate of 2 drums per stage. Presence of the scale inhibitor out in the virgin formation stops scale precipitation due to pressure changes, temperature changes, and incompatible fluids as the formation fluids and frac fluids commingle and migrate to the well bore.

A review of the monitoring for the presence of phosphate scale inhibitor on the two new method wells is not typical of most scale inhibitor squeezes. One notable difference is the spikes in the concentration of scale inhibitor indicated by the Scale Inhibitor Residual Chart. These spikes correlate to the fluctuation between the different sets of perforations as they begin to contribute more to the production. This verifies the need for scale inhibitor treatment in each stage of the frac. Treating each stage is important in controlling scale as incompatible waters mix in the formation and in the annulus of the well.

Since the beginning of the program 13 additional wells have been drilled and completed making a total of 26 wells on the lease. The first 13 wells were completed with the standard completion and the last 13 wells were completed with the new method of completion. The new method has been 100% effective with no failures, no positive bacteria tests and no reports of scale precipitation. The only work over to any of the new wells has been to one well with wear related issues.

To date over 600 stages have been completed using the above procedures during the frac. The results have been phenomenal; no reports of scale/iron sulfide, positive bacteria, and/or corrosion related failures have been observed.

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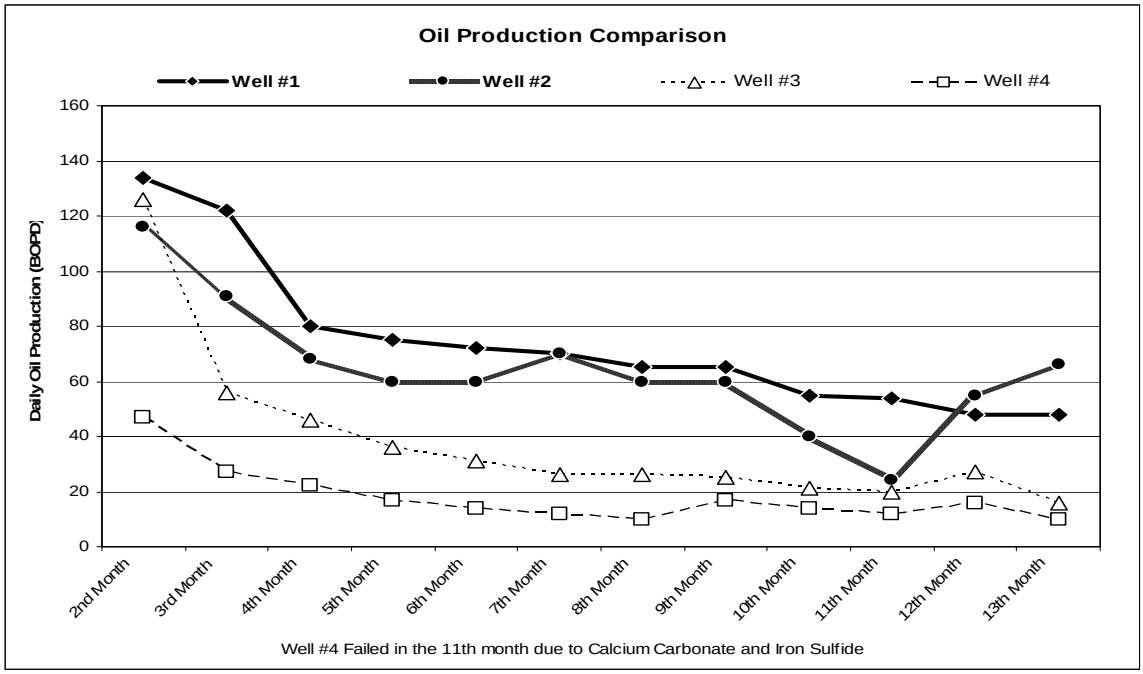
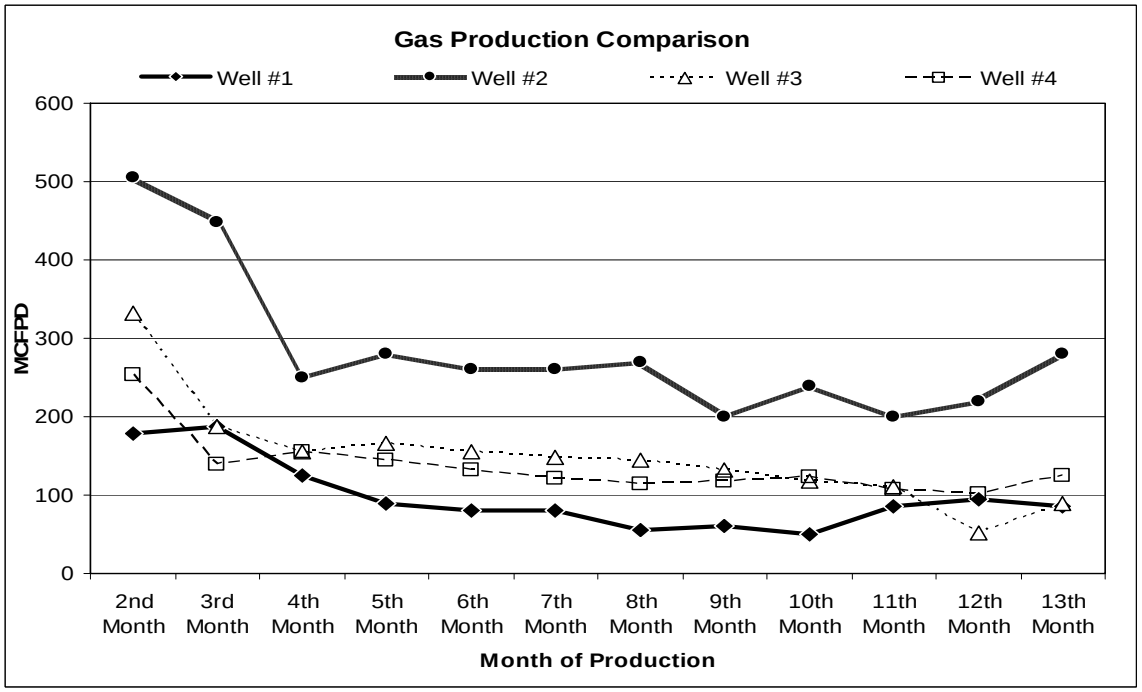
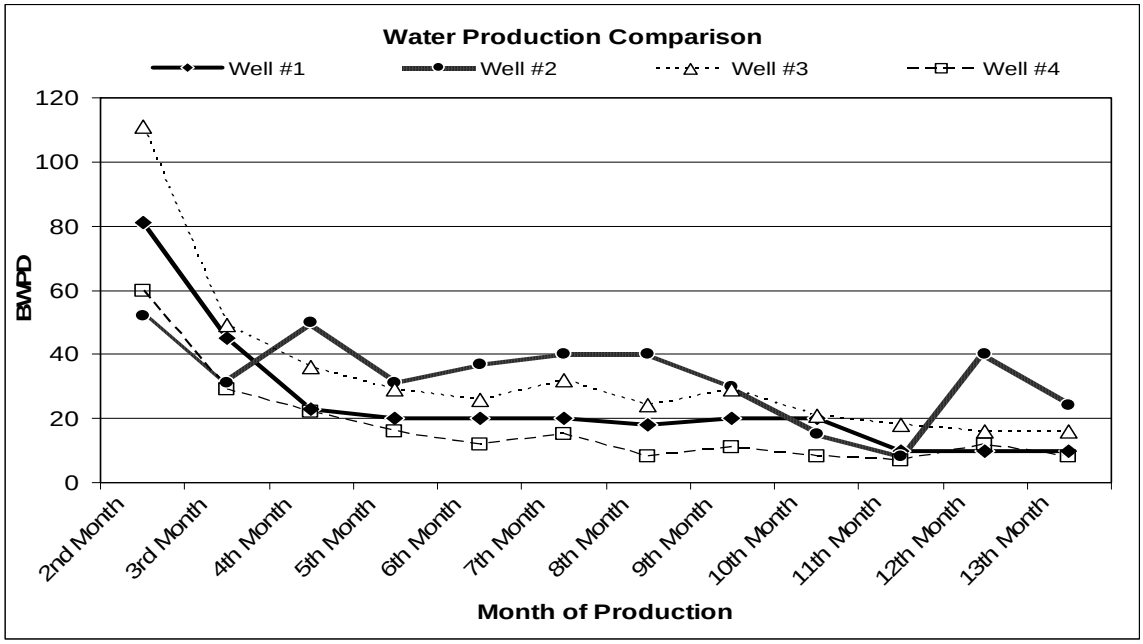
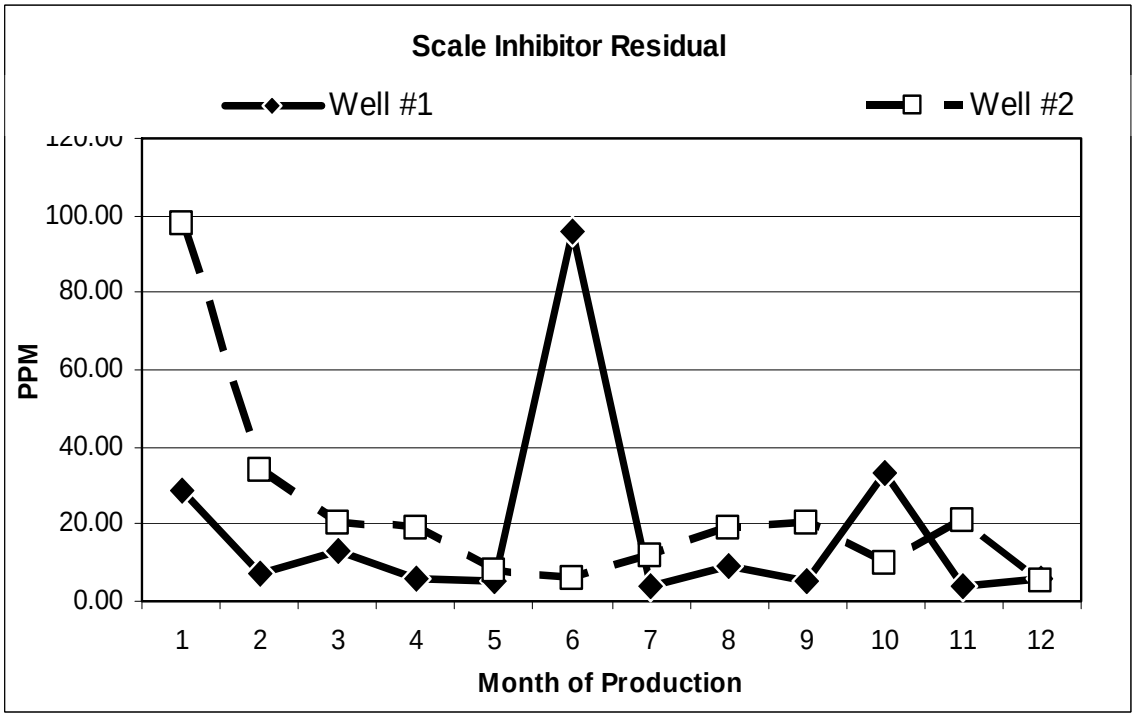





Water Production Comparison
Well #1
Well #2
Well #3
Well #4
120
100
80
60
40
20
0
BMPD
2nd Month
3rd Month
4th Month
5th Month
6th Month
7th Month
8th Month
9th Month
10th Month
11th Month
12th Month
13th Month
Month of Production


Scale Inhibitor Residual
Well #1
Well #2
100.00
80.00
60.00
40.00
20.00
0.00
PPM
1
2
3
4
5
6
7
8
9
10
11
12
Month of Production